ENGINEERING

UNIVERSITY OF MICHIGAN

this issue

EAR ABSOLUTE ZERO

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CONOMIC ROOFS

WHOLESALE COMPUTING

GENEVA DISTILLATE
Research Reactors

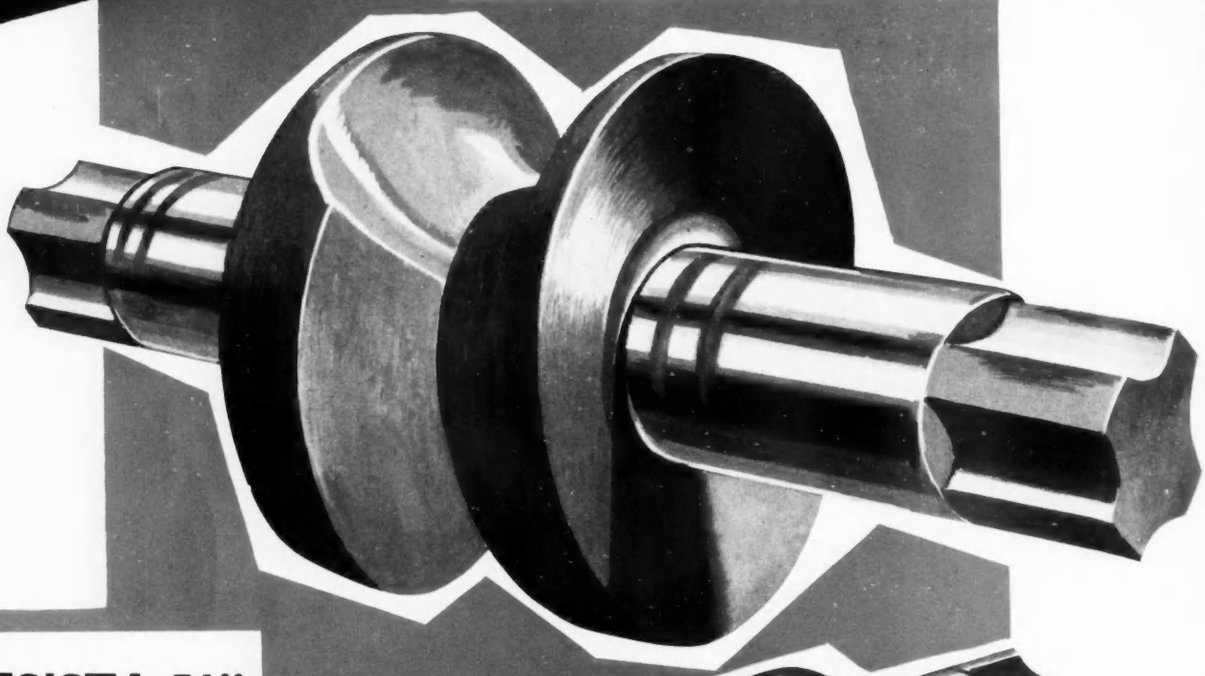
HOW TO RUN A RAILWAY

PRICE
2/-

Bearing Assembly

'RESISTA 51'

SPECIAL ALLOY STEEL PILGER ROLLS



"RESISTA 51"
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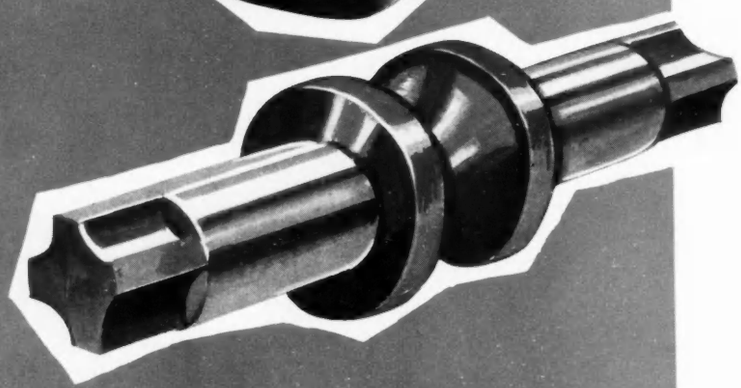

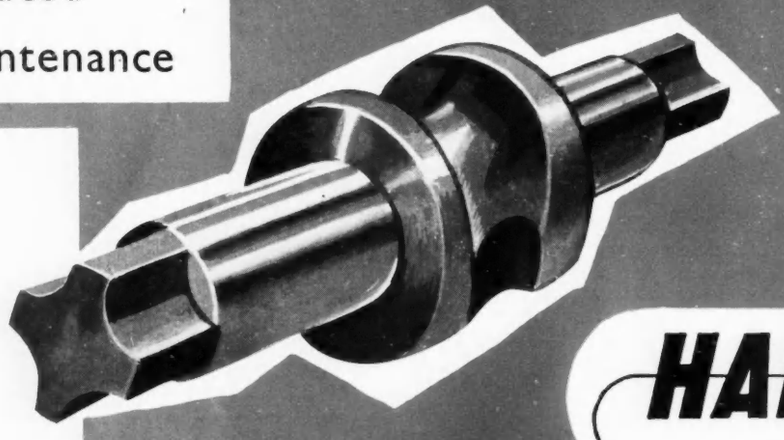

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Contents

653 **Leading Article**
Catalytic Corporation

654 **Plain Words**

661 **Companies in the News**

Special Article
662 Geneva Distillate: 5—Research Reactors
668 Wholesale Computing

665 **Atomic Review**
Cross Section

667 **In Parliament**

677 **Notices of Meetings**

681 **Book Reviews**
Scientific Uses of Earth Satellites
A History of Technology—Vol. V

681 **On the Shelf**

684 **Engineering at Home**
Trial by Usage

. . . . . .

654 **Management**
Weekly Survey

656 **Plant and Equipment**
Remote Controlled Roll Changing Mill
Pressure Ventilated Protective Suit
Variable Speed Drives
Reach Forklift Truck
Diaphragm Meter for Differential Pressures
Vehicle Suspension for Rough Country
Midget Locomotive
Unit Work Table
Line Tester
The German Mining Show
Bituminous Paver: Laying on Tracks and Travelling on Tyres
Low Draught Dredger Using Venturi Suction

660 **The Human Element**

671 **Design**
Bearings for Low Drift Gyros
Conveyor Belting: Endurance Lives of Terylene and Cotton compared
Compound Flow Fan
Assessing Ventilator Design
Fast Pilot Launch
Nylon Filters for Blast Furnace Sludge
Flexural Behaviour of Mild Steel Beams

675 **Production**
Quality Control and Development of Wiring Accessories
Gas by Grid

676 **Metals and Materials**
New Sheet and Wire Gauges?
Mist-Reducing Additives for Chromium Plating Baths

678 **Research and Development**
Research near Absolute Zero: Work in Progress at a University, a Government Establishment and an Industrial Laboratory

682 **Construction**
Economic Roofs: RAF Hangars at Abingdon
British Universal Beams in Workshop Frame

683 **Operation and Maintenance**
How to Run a Railway

Catalytic Corporation

THIS year the National Research Development Corporation celebrated its tenth birthday. At the end of November Britain's first electronic computer exhibition will be held at Olympia. The connection between these two events is the not generally realised fact that there would probably be no indigenous computer industry in this country if it were not for the existence of the Corporation. The original work in this country was carried out by Professor Williams, during the war, at the Telecommunications Research Establishment. As was pointed out in the House of Commons during the debate on the Government's Bill to extend the life and borrowing powers of the Corporation, when the war ended few foresaw the extraordinary speed with which the development and use of computers would take place.

The industries best suited to undertake this development were fully occupied with the problems of post-war reconstruction and with supplying their customers with their regular range of products. By comparison with the giant IBM Corporation in the United States, British companies in the accounting machine field were small; while the needs of the continental radar defence system were soon to provide an enormous concealed subsidy to the American industry, estimated to be of the order of $250 million. In this situation it is greatly to the credit of the Corporation, and especially of its retiring managing director, Lord Halsbury, that a flourishing industry should have grown up in this country based on the original patents held by the Corporation covering Professor Williams's work and on a programme of development contracts in industry, supervised by the Corporation's technical staff. Today, on the Corporation's initiative, there exists a common pool of patents in which all manufacturers share. It has been stated that the Corporation is now earning a dollar balance on its computer account, after allowing for the cost of establishing its patents in the United States.

This story alone would justify the faith of those who set up the Corporation, in face of some hostility, in 1948; but it is only part of the contribution which the Corporation is making to industrial innovation. Today it holds nearly 1,000 British and nearly 2,000 overseas patents. It has over 350 licensing agreements at home and abroad which are bringing in royalties amounting to nearly £200,000 a year, and these more than cover administrative expenses. There is every reason to believe that before the end of the life of its first patents, the Corporation will be paying its way, including the payment of interest on its loans. Among the engineering inventions on which the Corporation is obtaining revenue are the Bailey Bridge, the Denny-Brown ship stabiliser and the RAE gyroscopic control apparatus for aircraft. Among its most promising new or continuing projects are computer controlled machine tools. Mr. R. C. Clark's regenerative mechanical transmission system and Professor Hawthorne's flexible containers for towing oil.

The new Bill extends the Corporation's life to 20 years and its borrowing powers to £10 million, and its introduction provides the occasion to consider whether any changes are needed in its policy or operation. Nothing very drastic was proposed in the House of Commons, although it was suggested that greater use might be made of the research work that is carried out by the industrial research associations. The Corporation could be especially useful in stimulating innovations in traditional industries composed of small, under-capitalised firms with little scientific background. Many new techniques fall outside the expertise of both the manufacturers and their suppliers, and an outside organisation may be needed as a catalyst to initiate a new process.

A rather similar situation exists in the case of problems whose solutions may be of great social, or even economic, importance, but which are not likely to be of immediate profit to anyone and which fall between the responsibilities of two or more authorities. These the Corporation is empowered to deal with under Section 5 of the original Act, if asked to do so by a Government department which would make good the loss incurred. The recovery of sulphur from flue gases is a suitable candidate and the Corporation might well be able to speed up the dilatory work on the uses of small coal. A more elaborate and long-term project would be the development of a super-fast electronic computer for which there may not be an immediately foreseeable commercial market.

Perhaps the Corporation's most valuable function is the catalytic one which it performs by virtue of its contacts with industry, with research associations, with Government establishments and with the universities and colleges of technology. It is in a good position to overcome the barriers between pure research and its commercial exploitation; especially in the case of the universities, with their traditional reluctance to undertake sponsored research, and industry.

Cover Picture.—*The operator is shown assembling taper roller bearings. The rollers are hopper fed and loaded by means of a hand-actuated metering device. Transfer of the assembly to a small pneumatic press begins the cage-closing operation.*

(*Nurnberg photograph for* ENGINEERING)

Some confusion has arisen from the caption for our cover picture of 7 November. The picture showed a cable being sheathed with pvc; the cable, for low-voltage mains, was paper insulated and aluminium sheathed, the pvc being applied to provide protection against corrosion. The use of an aluminium sheath achieves a considerable reduction in weight over the more normal lead-sheathed and armoured cable.

As a further example to illustrate the weight that can be saved by the employment of modern materials, details were given of a 11·5 kV cable for underwater use. This cable was polythene-insulated, with screened cores, pvc sheathed, armoured with galvanised steel wire (each wire being covered with pvc) and with a jute serving over all. As stated in the original caption, about two miles of this 11·5 kV could be wound on a drum and weigh no more than 20 tons.

Plain Words

Why is it that relatively efficient organisations come in for heavy criticism whereas blatently inefficient parties all too often get away without a slating? Much the same also applies to individuals—as most of us learn to our discomfort—but that is another story.

I am reminded of the evils of being good but not good enough by some remarks made by Mr. C. T. Melling, who comes from the CEGB, when speaking a week or so ago at an Electrical Industries Club luncheon. He pointed out that last year the gross load factor of the CEGB (and its predecessor the CEA) was 48·1 per cent. For that the Board are constantly criticised and exhorted to do better. Yet they reached this figure on the basis of round the clock working—168 hours a week, 52 weeks a year—and with their consumers able to have what electricity they wanted when they wanted.

Mr. Melling quoted a case of much smaller load factors. For good measure he stated that the load factors of railways, buses, theatres, cinemas, restaurants and shops were all low compared with that of the electricity supply industry. He later observed—some readers may be pleased to learn—that no criticisms are made about these industries and services. In support of his contention he had argued the case of shops: 5½ days a week, with between 50 and 60 per cent of their trade done on Fridays and Saturdays, representing a load factor of 10 per cent or less. Any London theatre—though not the Windmill—also reached 10; " My Fair Lady " weighed in at 14 per cent. For " services " operating successfully at factors of 1 per cent he mentioned football grounds and race-courses.

Mr. Melling—after an EIC lunch—was speaking to the converted. But he made his case: the electrical supply industry got a good proportion of capital investment and must give maximum value. A high load factor was essential. Consumers had got to be enabled and induced to use off-peak supplies. The practical maximum he put at 84 per cent. A long way to go—but an imperative objective.

CAPRICORN

Weekly Survey

Electrical Underload

Planning the trend of electricity consumption is much more difficult than appears on the surface. There is much more to it than extrapolating the known statistics about industrial production and the national income, or accepting rough and ready estimates about the trend of industrial output over the next few years. The need to revise downward the electrical generation programme about a year ago, when it became apparent that industrial output might show a trend in the future which would be quite different from the recent past, was a warning that the exercise is more intricate than might appear. Forecasting of this kind requires a good deal more emphasis on the hypotheses from which it starts, and a more thorough study of consumers' requirements than has been common in past years.

The intricacies of these problems were touched on in an address by Mr. D. P. Sayers in a paper called " Art, Craft and Rampart," to the Institution of Electrical Engineers on 29 October. He pointed out that the engineer has to design equipment not only for a specific load or performance, but to judge which performance should be selected as the basis for design. There are nearly 15 million consumers of electricity in this country, and they are increasing at a rate of 400,000 a year. There is inevitably a wide gap between the capacity provided and the average capacity utilised. This leads to problems not only of overloading at peak periods, but of underloading at off periods, and he made a plea for a study of underloading mains and transformers as well as the more notorious and highly publicised problem of overloading.

He also emphasised the need for more accurate knowledge to enable the planning engineer to fit the right size of cable. Cable costs are a large item in distribution expenditure. Some progress has been made with plastics-insulated cables, which has been further stimulated by the wide fluctuations in the price of copper, a problem which has also increased the use of aluminium conductors for both overhead lines and insulated cables.

Crisis for European Trade

Few thought, when the idea of a European Economic Community and an appended Free Trade Area was developed out of the trend towards a more liberal trade policy in Western Europe, that the desire for progress would build up into a crisis for the whole structure of Western European trade. The French have all along been attracted to the idea of a Western European zone protected by high tariffs to defend high cost producers, and they have dragged their heels more than most in reducing tariffs and increasing quotas. If the idea of the FTA does not become a tangible organisation, there is some danger that the whole fabric of the Organisation for European Economic Co-operation will collapse. The announcement by M. Soustelle in Paris last weekend on behalf of the French Government adds more confusion and pessimism to the situation than constructive comment.

The growth of OEEC and its subsidiary organisation, the European Payments Union, has been built up on two basic ideas. These have been, first, that the nations of Western Europe have a common interest in keeping their different economies in step and that they do not, for instance, try to export unemployment to one another. The second has been that the wish to pursue compatible economic policies must be followed by the creation of an administrative machine and a policy in action which will enable Western Europe to behave as something approaching an economic unity. OEEC has thrived because the first of these ideas has been practicable, and because governments have been willing to will the means of putting a modest degree of economic integration into effect.

The European Economic Community (the European Common Market) gained many adherents in the six countries concerned because it promised to be one step towards the political as well as the economic integration of Europe. It is very apparent, however, that the French, and to some extent the Italians and Belgians, will see the development of the Community only in terms of high tariff protection. Thus, the British idea of a loose association of sovereign nations in Western Europe, united mainly by a wish to free their mutual trade, is far removed from the views about the European Economic Community held by the Latin members. These basic differences make it all the more difficult to be optimistic about progress being made with the Free Trade Area. Unfortunately, lack of progress may mean more than stalemate; it could be the end of OEEC.

Policy for Flying Solo

The Minister of Transport and Civil Aviation last week gave some broad hints that changes may be made in the structure of United Kingdom civil air transport policy. Keeping a fair balance between the independent airlines and the Corporations is a difficult task, and while the Government could not renounce responsibility for ultimate policy decisions, Mr. Watkinson suggested it might be possible to devise a new statutory authority to handle the increasingly complex day-to-day matters at present dealt with by the Ministry.

It has for long been argued that the independent airlines were hard done by. Whatever the merits of this argument, member airlines of the British Independent Air Transport Association provided last year about 25 per cent of the capacity ton-miles available from British airlines as a whole. This is an appreciable proportion, and it is important that future developments, particularly relating to fares, should not prejudice the independents' position.

The Minister and the Association are in agreement that in the increasingly competitive time ahead, lower fares are the key to expansion and profitability. The independent airlines have already made considerable progress in tapping the cheap inclusive holiday tour market, and Mr. Watkinson said he was determined that any moves by the Corporations towards economy-class flights should not prejudice these efforts.

The suggestion has been put forward by the BIATA that there is a case for providing for the licensing of public air services so that standards of operation and reliability could be made subject to some positive check. This suggestion is being studied, and Mr. Watkinson felt it possible that the right machinery for handling the air transport industry might be devised in the light of the suggestion in the form of a new type of Air Transport Advisory Council with new powers, and wider terms of reference.

Falling Timber

So far 1958 has not been a good year for the European timber market according to a recent ECE report. But after five years of stability the present setback which cannot be compared with earlier recessions, looms perhaps a little larger than life size. With constructional programmes slowed down on the previous year demand for timber has fallen while present high stocks are run down. In the United Kingdom the release to the trade of the last batch of government-held stocks cut down import requirements. Not surprisingly timber

prices have fallen in most European countries. On the supply side exports for 1958 from Austria, Czechoslovakia, Finland and the USSR are likely to be greater than at first estimated. Supplies from Canada have not increased to the extent expected.

Looking to the future the report anticipates increased demand for timber both for building and furniture making next year. One reason for this is the recent easing of credit conditions and hire-purchase terms. Increased imports of temperate and tropical hardwood logs for the plywood industry are expected in 1959. Pitprop requirements are likely to be down this year, and export prices have fallen by as much as 20 per cent. This falling off is only partly explained by the drop in coal output. In several countries steel props are being increasingly used in place of timber.

The American recession has cut imports of timber products from Europe. Exports from Finland of chemical and mechanical wood pulp, board and paper fell by from 15 to 35 per cent. Swedish exports to the USA, however, mainly of chemical wood pulp dropped by only 2 per cent. Now with the revival of activity in the United States it is expected that the market for timber will improve in the next twelve months.

Europe to Control its Traffic

A set of rules governing international road transport in Europe is to come into operation shortly. These have been incorporated in a general agreement drawn up by the Inland Transport Committee of the United Nations Economic Commission for Europe (ECE). At present four countries, Italy, Greece, France and Norway, have signed the agreement which requires a further signature before it can come into force. A number of the representatives at the recent meeting of the ECE Road Transport Sub-Committee said that their countries would be signing in the near future. Among the problems dealt with are hours of work of transport crews, signposting, road markings, signals on priority vehicles, and the maximum permissible axle loading for heavy vehicles. One development may be the adoption of a new form of distinctive sign for vehicles in international traffic. These would replace or at any rate supplement the present signs of the "GB" type. Apart from representatives of member countries, including Britain, these meetings are attended by a number of international organisations such as the International Union of Railways, International Road Transport Association and the World Touring and Automobile Association.

Feeding the Railways

The Presidential Address by Mr. A. B. B. Valentine to the Railway Students' Association, entitled "The Revolution on the Railways in the Freight Field," answered a number of criticisms of the modernisation programme, which have been intensified by the recent announcement that the British Transport Commission expects to show a loss of about £85 million for 1958. Mr. Valentine dealt first with the criticism that the amount to be spent on the railways, £1,500 million over 15 years, is excessive in relation, for example, to expenditure on road transport. He pointed out that only £100 million relates to railroad track, bridges, etc., and a further £100 million to signalling. This represents about £14 million per annum compared with the minimum level of £60 million per annum to be spent on new roads and road improvements over the next few years. If comparison is to be made with the full £1,500 million then expenditure on road transport must include the cost of road vehicles, other than private cars, which he estimates over the 15 years period at £4,500 million.

In order to put the modernisation programm in perspective, Mr. Valentine outlined the historical background, pointing out that, because the locomotive was developed before the internal combustion engine, the main pattern of inland transport took the form of an extensive system of specialised track with a very large number of stations from which delivery could be made by horse and cart to practically all communities. Far from being designed to extend the railway system, the modernisation programme is designed to take into account the possibilities of economic delivery from a much smaller number of stations by modern road transport. The necessary pruning is, however, made very difficult by the need to present schemes piece-meal to the consultative committees.

Mr. Valentine is confident that once the necessary re-arrangement has been carried out and a satisfactory system of charging been developed, the modernised railway system can win a much larger share of general merchandise traffic than it enjoys at present. Today 90 per cent of the tonnage of freight carried by the railways is forwarded from private sidings and ports and nearly 75 per cent is delivered to private sidings and ports using rail transport throughout. In Mr. Valentine's view, modern developments in transhipment from road to rail and vice versa will enable the railways to increase substantially their share of other traffic.

Strength of Steel

Last year, although steel production in Western Europe, and indeed the world as a whole, was at a record level, the rate of expansion was down on the previous year. West European steel suffered its second check since the war but there were considerable differences between countries. A recent ECE survey shows that the weakening of the steel market began in the United States, spread to Belgium and Luxembourg, both exporters, and then to other West European countries. Beyond the Iron Curtain steel production continued to rise steadily.

The fall in home demand was the chief cause of the weakness in the steel market. But there were considerable variations from one sector to another. In general the industries which are big direct users of steel, notably the makers of motor vehicles and consumer durables of all sorts, were flourishing. Demand in the ship-building industry remained high although there was a fall in new orders. On the other hand, except in France, the drop in capital investment led to a fall in demand for steel. This was felt mainly by commercial and industrial building and in civil engineering. Mechanical and electrical engineering felt the impact of restrictive government policies much less.

On the supply side the survey forecasts that the steady growth of iron and steel making capacity in Western Europe is likely to continue in the coming years. So far as the fortunes of the industry in the United Kingdom are concerned the motor industry, electrical machinery including appliances, and metal products will largely determine the level of demand. The conclusion of the ECE experts is that the recent weakening of the steel market was of a temporary nature and that no major revision of long-term plans or forecasts is called for.

Cross Management

A new edition of Colonel Lyndall Urwick's book *Is Management a Profession*? has been published in booklet form—"a new and professional-looking format"—by Urwick, Orr and Partners. It has been re-issued because Colonel Urwick strongly disagrees with the current trend away from "the professional approach to the art of managing" of which he has been a strong advocate for many years. The dissolution of the Institute of Industrial Administration—which formerly awarded professional qualifications in management—and the likely curtailment of the Ministry of Education's scheme of management studies operating the "Urwick Syllabus" of 1947, were quoted as evidence of this trend. The gradual shrinkage in the British Institute of Management's strengthened activies is additional evidence that Colonel Urwick's notion is right.

The British Transport Commission are seeking their own salvation through the setting up of a British Transport Staff College for Higher Management. The object, they say, is "to provide advanced training for younger officers in all the Commission's services." Major General W. D. A. Williams has been appointed principal and will take up his duties next spring. He will answer to a governing body, headed by Sir Brian Robertson, whose members are all with the BTC in a full, or part-time capacity.

This move by BTC is open to the criticism that the Railways already suffer badly from "in-breeding" and would do well to broaden their staff's outlook by having them trained side by side with staff of other industries in one of the many colleges which exist. It is a reaction presumably from the trend Colonel Urwick is fighting against. If management were recognised as a profession, and managers were trained as professional men are trained, the need for the BTC's staff college would not exist, and the BTC might be the better for it in ten years' time.

TUNNEL PROSPECT

A preliminary Sonar survey made during last summer of the bed of the English Channel failed to disclose any faults in the geological structure which would constitute an insuperable obstacle to the construction of a tunnel between England and France.

During the last 12 months the Channel Tunnel Study Group—comprising the English and French Channel Tunnel Companies, the IRF (Paris office), the Suez Canal Company and the American company, Technical Studies Inc.—have put in some hard work to test the feasibility of the project. Two studies have been begun: one to find out the nature of the ground to be tunnelled through and therefore the engineering practicability, the other is an economic study to show that it is a sound financial proposition. In addition, the existing shaft and pilot tunnel on the French side, which had been submerged since 1883, have been pumped out. They were found to be in remarkably good condition and the amount of water entering was significantly small.

The next steps are to complete the interpretation of last year's survey and prepare for next season's work, which will be completed by some borings through the Channel bed. The traffic study, handled from the British side by the Economist Intelligence Unit of London, was begun last summer and is expected to be completed in six months time. It will attempt to predict the volume of traffic which might be expected, including the implications of a closer economic integration within the Continent.

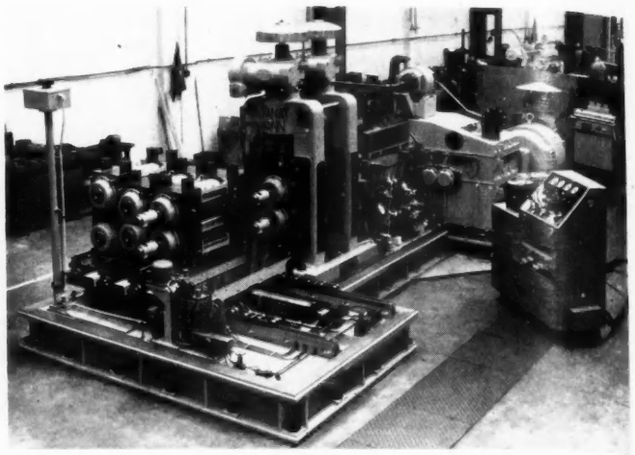
Then will come the correlation of the traffic forecasts and revenue prospects with the estimated costs of different types of tunnel. The point that will surely be at issue is this: can a sufficient number of potential users be interested in a railway-only tunnel. The Study Group hopes to make its final report by the end of 1959.

THE LATE SIR WILLIAM HALCROW

In our obituary notice of Sir William Halcrow, page 592 of our issue of 7 November, we reported that he died on Friday, 31 August, instead of Friday, 31 October. We very much regret any embarrassment that has been caused to Sir William's family, and his Partners.

Plant and Equipment

REMOTELY CONTROLLED ROLL CHANGING MILL

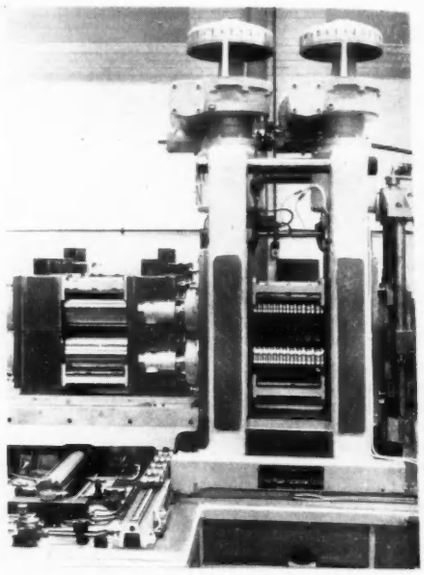


General view of the mill, which is intended for use in a sealed box. The magazine of rolls is on the left, the control desk on the right.

The rolling of toxic materials is becoming a manufacturing process of increased importance to the nuclear power industry. Recently, a 10 in diameter, 14 in face width, mill for rolling such materials in an inert atmosphere has been produced by Albert Mann's Engineering Company Limited, Basildon Industrial Estate, Essex. Automatic change of the roll assemblies is accomplished at the touch of a button.

The complete unit, shown in the illustrations, contains a two-high hot breakdown mill, a two-high cold intermediate mill, a four-high cold sheet finishing mill, and a form rolling mill. A switch on the control console allows the selection of any one of the four roll assemblies and, after the initiation of the automatic change-over process, the required assembly is inserted in place and connected to the main drive. Electro-hydraulic operation is used and the sequence of events is as follows. The screw-down is disconnected from the top roll and elevated to a position that will accept any roll configuration; the jibs retaining the chocks in position are withdrawn and the roll assembly itself is withdrawn on to the roll carriage. During the withdrawal, which is accomplished by a screw driven by a hydraulic motor, the universal spindles are supported. The carriage carrying the set of four rolls is then moved horizontally by a hydraulic jack until the selected roll assembly is in line with the mill. After the adjustment of the universal spindles to cater for the roll centres of the selected assembly, the latter is slid into the mill under the action of a screw. It is locked into position by the jibs entering the chocks, and the screw-down mechanism collects the new top roll assembly.

The mill shown is a Stanat Mann mill, constructed for Commissariat a l'Energie Atomique, France. It has a 600,000 lb maximum rolling load capacity at a speed of 100 ft per min, and is arranged for sealing within a glove-box enclosure with the reduction gears, pinion stand, and drive motor mounted outside. A combined Timken mounted double helical reduction gear and pinion stand, designed at Basildon, transmits the torque to the universal joint spindles, the gearbox itself being driven by a Crompton Parkinson 26/100/100 h.p., 200/750/1,500 r.p.m. compound wound motor with separate excitation. This is supplied by a Ward-Lennard set comprising a Crompton Parkinson 1,450 r.p.m. 0-420V, 191A, shunt-wound motor-generator set mounted on a common bed plate.



Close-up of entry side of mill showing grooved rod rolls in position. The hydraulic jack controlling the position of the roll carriage is seen on the left.

The rolls are adjusted by means of a direct current motor rated at 2 h.p. It operates at variable speeds through a double worm reduction to the screwdown spindles, a magnetic clutch enabling individual adjustment of each side of the mill to take place. Screw-down speeds are variable from 0·18 mm per sec for cold rolling to 2·6 mm per sec for hot rolling. The screw-down motor is located outside the glovebox enclosure because of the detrimental effect on the equipment should arcing take place on the motor armature with an inert atmosphere.

Left-hand or right-hand roll pressure, or the sum of both, can be read at the control desk. The pressures are measured on load cells situated between the screw-down and the top roll chocks. Measurement can also be made of the upper roll neck torque, lower roll neck torque, and the sum of both. These are measured on the universal driving spindles by strain gauges, the signals being transmitted by slip rings and brushes mounted on the universal joints.

PRESSURE VENTILATED PROTECTIVE SUIT

A new type of protective suit made with Geon pvc sheeting has recently been introduced jointly by Spembly Limited, Manor Road, Chatham, Kent, and Plysu Products Limited, Woburn Sands, Bletchley, Bucks. Designed and developed primarily to fulfil the requirements of the United Kingdom Atomic Energy Authority this suit affords the wearer complete protection against radioactive dust while allowing maximum freedom of movement.

Special features of the suit include full ventilation to the body extremities, and a helmet air supply, both controlled by the wearer; reduced fatigue since the weight of the air hose is taken by a special harness; and unrestricted vision in all directions.

A pvc pressurised suit gives protection against radioactive dust, toxic gases or other contamination.

VARIABLE SPEED DRIVES

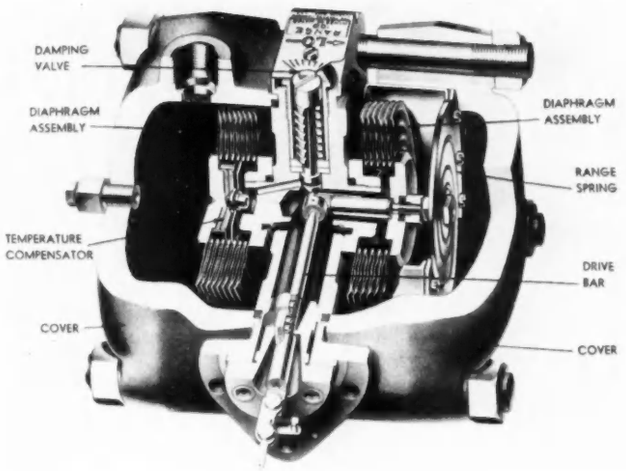
It is announced by Lancashire Dynamo Nevelin Limited, Oxted, Surrey, that their range of Varimag variable speed drives has been extended to include three-phase units up to 10 h.p. Models are available for powers from 3 to 10 h.p. giving speed ranges of 20 : 1. The motor may be switched direct on at any speed and load.

REACH FORKLIFT TRUCK

The reach forklift truck allows operation in narrower gangways than the type in which the forks remain at a fixed distance from the body. The 30 cwt model introduced by Wessex Industries (Poole) Limited, Dolphin Works, West Street, Poole, Dorset, can stack 40 in by 48 in pallets in 80 in gangways. In this truck the mast is capable of being retracted 24 in from the fully forward position; there is a free lift of 6 ft before the mast is extended to give the full height of 12 ft; and the drive wheel and power unit can turn through 180°. The truck is battery powered.

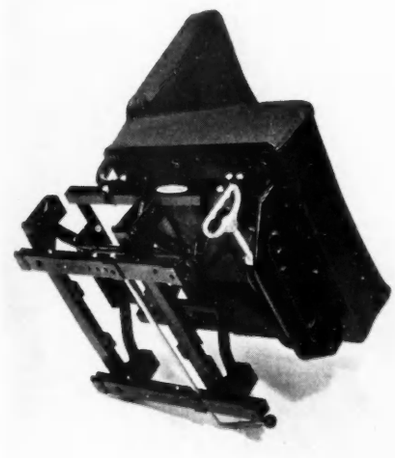
DIAPHRAGM METER FOR DIFFERENTIAL PRESSURES

A diaphragm differential pressure meter that does not involve the use of mercury has recently been introduced by Foxboro-Yoxall Limited, Redhill, Surrey, and is shown in part section in the diagram. It will measure pressure differentials from 20 to 200 in of water at static pressures up to 2,000 lb per sq. in. The diaphragm is made up of preformed discs welded and shaped to nest together, and welded to spacing rings. The latter form a metal-to-metal stop when the discs are fully compressed. The drive unit is made up of solid rods joined by a metal flexure and forms a direct connection between the diaphragm assembly and the pen lever. The fulcrum is made up of two similar flexures and the seal is flexible bellows. There is built-in temperature compensation and full range damping adjustable under pressure.



Diaphragm differential pressure meter.

VEHICLE SEAT SUSPENSION FOR ROUGH COUNTRY



The accompanying illustration shows the construction of the Leveroll " Level-Ride " system of seat suspension. It is made by A. W. Chapman Limited, Ranelagh Gardens, Fulham, London, S.W.6, and is designed particularly for vehicles operating over rough country. The system consists of a series of links operating in conjunction with two rubber torsion springs. There is a wide adjustment for individual weights of drivers and the suspension is also provided with fore-and-aft adjustment but not at present with adjustment for height. It was displayed at the recent Commercial Motor Show.

To eliminate vibration this seat is mounted on a system of levers and rubber torsion springs.

UNIT WORK TABLE

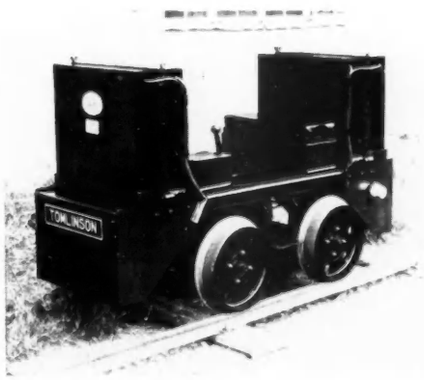
The work table shown in the illustration is made by Farrow and Jackson Limited, 41-42 Prescot Street, London, E.1, and is designed on the unit principle, so that several can be joined together to make up a chosen formation. The basic unit consists of top, end leg and centre leg sections with the necessary bracing bars, screws and bolts.

Unit table for general working.

Each unit measures 2 ft 9 in square by 2 ft 9 in high; adjustable feet are fitted to allow for inequalities in the floor. The legs are square hollow sections coated with hammer finish paint. The tops can be of several materials.

MIDGET LOCOMOTIVE

A midget battery-operated locomotive has been built by Tomlinson (Electric Vehicles) Limited, Minster Lovell, Oxford, for use inside the Rock of Gibraltar. The batteries were made by Chloride Batteries Limited, Clifton Junction, Manchester. The line on which the locomotive will operate is for the construction of rainwater catchment areas; it is about ¾ mile long, of which some 700 yards are in a tunnel through the Rock itself. The locomotive measures 2 ft 4 in wide overall and 5 ft 6 in long, running on a 24 in track. It will pull up to 2 tons at a top speed of 6 m.p.h. The motor is reversible, series wound and rated at 2¼ h.p. at 2,400 r.p.m. The control arm allows all braking and acceleration to be carried out with one hand, but the reverse lever requires both hands to engage it. This is to prevent it being used as a brake. The controller has three steps.



Miniature locomotive for use inside the Rock of Gibraltar.

LINE TESTER

A fixed-prod voltage tester for lines up to 600 V, direct or alternating current, is being made by the Martindale Electric Company Limited, Westmorland Road, London, S.W.9. One of the prods is incorporated actually in the body of the tester and both have spring-loaded sheathes which afford protection until the prod is pushed against the surface. The search prod contains a high rupturing capacity fuse in series with a current-limiting resistance of 68 ohms. The body is constructed from high-impact plastics and has a built-in magnifier to make the indicating disc easier to read. The tester will indicate " live " and " earth," and whether the supply is direct or alternating.

Continuing **Plant and Equipment**

COAL CUTTING *and* TREATMENT PLANT

The German Mining Show

The 532 exhibitors representing seven countries made the mining show at Essen, the fifth of the series, by far the largest held to date. The seven sections, including mine safety and coal technology, were housed in 20 halls and over a large open area. As was to be expected, most of the methods and equipment on view were suitable for Continental application and could only be applied to British practice after some adaptation or modification. Despite this, a large British contingent, including many officials from the National Coal Board, toured the show as did other large parties from France and Japan. A relatively large Russian delegation also attended, reportedly only with the object of gathering information and without placing any substantial orders for equipment.

British industry was represented by Dosco Overseas Engineering Limited (a member of the Hawker Siddeley group), of Beaconsfield, Buckinghamshire, showing miner cutting and loading machines; Herculare Limited, of Alton, Hampshire, showing linings for shafts and underground roadways in the form of double wedge-shaped concrete blocks, and reinforced lagging for steel supports; Olin Mathieson, of London, demonstrated Armstrong compressed-air shooting equipment, and Austin Hopkinson and Company Limited, of Audenshaw, showed Pikrose automatic hydraulic haulage gear with auxiliary equipment. The only "satellite" exhibitor was Nikek, a government-sponsored trading association for heavy industrial equipment, who showed winches, charging machines, and flameproof priming machines.

One of the newer German machines which drew attention was the Peissenberg-type ram plough exhibited on the Westfalia Luenen stand. An official of the NCB commented that a mining unit of this kind could be ideal for working pitches over 25° particularly where the seams were thin. In place of the standard two-speed drive unit as fitted, he advocated the employment of an infinitely-variable speed transmission which would allow the ram body speed to be matched to all face conditions.

Most of the coal-getting machines and equipment at the Essen exhibition could readily be adapted to British requirements. Korfmann (of Witten/Ruhr) showed a three-head boring miner which is fitted with two separately-driven trim chains. The top chain is designed so that it can be hydraulically raised and lowered while coal-getting to give continuous control of the cutting height so that the contour of the seam can be followed. Korfmann engineers say that this is the only continuous miner for cutting entries at 30° pitches. A new Eickhoff (of Bochum) shearer-loader has an additional roof-cutting drum which can be hydraulically lifted and lowered during mining to follow the course of the seam. Tungsten-carbide tipped picks located on both mining drums plough out coal from the face and feed it on to a deflector unit which drops it down on to the face conveyor. With a 1 ft spacer inserted into the drum arm, the upper drum will top cut seams up to a maximum height of 7 ft.

A new torsion prop demonstrated by the Gütthoffnungshütte (of Sterkrade) had as its main feature foolproof hydraulic tensioning of the yoke to eliminate completely any manual driving home of wedges. The design is said to be capable of even load acceptance, adjustable to conditions at the coal face. Hausherr (of Sprockhoevel) showed their improved automatic high-pressure water infusors. Water and air entering the infusor at about 68 lb per sq. in are squirted in a continuous stream into holes drilled in the rock or coal face at a final pressure of about 4,000 lb per sq. in. A new welding locomotive by Ruhrdynamo (of Duisburg) is said to be powerful enough to haul its own maintenance and car crew. The locomotive cab on this interesting type is designed to fold together in order to reduce overall buffer length from 90 to 70 in, so that the locomotive can be manoeuvred easily through staple shafts and narrow gateways. The welding range available from the generator extends from 50 to 300 amperes.

On a large open-air stand, Becker-Prünte (of Datteln) demonstrated haulage equipment intended, in the main, for use underground. Any number of lightweight steel-construction skips are coupled-up end to end by lengths of rubber, flexible and long enough to allow the train to negotiate sharp curves and bends. The flexible rubber couplings interposed between the skips allow the train to be run over a section of upward-curved dumping rails so arranged that the skip wheels are prevented from jumping the rails as the skips are up-ended to the side in order to dump their load into a discharge pit or waiting cars.

Shown for the first time, a germanium rectifier exhibited by the Allgemeine Elektrizitaets Gesellschaft (AEG) (of Frankfurt/Main) is said to be capable of simultaneously charging four large batteries coupled up to the charger in parallel. A particular feature of the unit is its three distinct charging phases; a constant heavy charge until the battery voltage reaches 2·4 volts per cell, followed by a decreasing rate to hold the voltage at that figure (± 1 per cent), and a final phase in which the charging current is held constant to boost the voltage to 2·6 volts per cell.

Though not directly connected with mining, a radioactive device for controlling the level of sludge in settling basins and the like drew the attention of mining engineers. A height-adjustable radioactive source installed at one side of the settling basin is arranged so that the rays from an isotope are directed towards a counting mechanism, also adjustable for height on the other side of the basin. Any interruption to the passage of rays across the basin due to the build-up of sludge will actuate the counter and start the sludge pumps to evacuate the basin. At the lower end of the sludge discharge pipe, and arranged vertically below the isotope container, a second counter comes into action as soon as sludge-free water flowing through the discharge pipe allows an uninterrupted flow of radioactive rays between isotope and counter. Pulses from the counter serve to switch off the sludge pumps.

Much of the equipment shown at the Essen Mining Show was exhibited out of doors.

As at every large exhibition, background is always provided by large and varied numbers of smaller but essential auxiliary equipment; the Essen show was no exception. For example, the Rolandswerk (of Essen) showed their new self-lubricating belt pulleys. Oil contained in a tank-like outer flange of the pulley seeps slowly through a porous sinter-metal bushing located round the spindle of the pulley.

BITUMINOUS PAVER

Laying on Tracks and Travelling on Tyres

ON the Jack Olding stand at the Public Works Exhibition was the new Barber-Greene machine for laying and finishing bituminous road surfaces. The machine—known as the 873 Finisher—was being exhibited for the first time outside the United States. It retains the automatic-tamping and levelling principle of operation that has been used on earlier machines from the same maker, but has the new feature of combining the benefits of crawler and pneumatic-tyred mounting while, it is claimed, eliminating the shortcomings of both. The two illustrations show how this is accomplished.

In this model, advantage has been taken of the stability and flotation of crawler tracks over rough bases or in confined areas when laying the surface; during this operation the wheels are retracted. For moving between jobs advantage is taken of the higher speed of the rubber-tyred wheels. The wheels are set outside the tracks but are within the 8 ft overall width of the main chassis. For towing they are lowered by hydraulic rams and a towbar attached to the front of the machine. Preparing model 873 for inter-site movement takes only a few moments.

The new Barber-Greene Finisher at work with tyred-wheels retracted.

The Finisher ready for travelling to a new site.

A modern steering control has been fitted to the machine. Instead of independent clutch-control levers, the driver operates a single joy-stick. Movement of the joystick in the desired direction of travel brings a prompt response with a turn into the line of work.

The hopper has been designed as the best compromise between a good capacity and an adequate truck clearance when loading, while avoiding the danger of "dead areas" which result from too little slope in the angle of the hopper sides. During work the hopper sides are opened out from 10 ft to the travel width of 8 ft. As the material is fed back to the screed, the operator can raise the hopper to assist discharge with little or no hand shovelling. An additional control of the flow of material to the spreader screws is obtained from a hydraulically powered deflector blade mounted above the rear end of the hopper feeder.

The screed unit has a hydraulic lift. The profile control is of the same pattern as the larger B-G Finishers. Bottled gas is used to heat the screed and, as the gas is under pressure, no blower is required. The tampers are driven at 1,500 r.p.m.

Performance details are as follows. The standard laying width is 8 ft, variable between 6 and 12 ft in increments of 3 in, using cut-off shoes or extensions. The thickness of the laid mat is variable from $\frac{1}{4}$ in upwards. Four laying speeds are provided, ranging from 7·66 to 49 ft per min. When travelling in its tracks the machine has a forward speed of $2\frac{1}{2}$ m.p.h. and 1·82 m.p.h. in reverse. The hopper capacity is 3 tons. For use in the United Kingdom a diesel engine of around 27 h.p. will be fitted. The all-up weight is about 12,100 lb. As a typical working figure the makers say the machine will lay an 8 ft wide mat, 2 in thick, at a speed of 7·6 ft per min; it will then use between 28 and 33 tons of material an hour, depending on density of the bitumen being delivered.

With the new emphasis on the road programme in the British Isles and the entry of class contractors who can and do afford good equipment, this and similar machines have a bright future in this country. Continued encouragement from the Ministry of Transport to complete road projects in a reasonable period will do much to eliminate from the market the shoddy machines which have previously been thought adequate for road work.

LOW-DRAUGHT DREDGER USING VENTURI SUCTION

A small dredger, well suited for the work of de-silting rivers, land reclamation and gravel-pit operations, has been designed around high-pressure water pumps as the only principal machinery installed. The water under pressure is forced through a throated venturi tube and creates a partial vacuum in the bottom 10 ft of the suction pipe. From a second outlet from each pump more water is taken for high pressure jets which are used to disintegrate the material to be dredged. With these arrangements it has proved possible to eliminate the sludge pumps required in conventional suction dredgers. Connected directly to the suction pipe is a discharge pipe which enables the resultant slurry to be deposited as much as 1,000 ft away.

A small version of the dredger, with a capacity of winning between 45 and 65 cu. yd of solids per hour and delivered 600 ft away at 6 ft elevation, was recently demonstrated on the Great Ouse at St. Ives, Huntingdonshire. The machine has been developed and built by Acrow (Engineers) Limited at their Coronation Works, Saffron Walden, Essex, and is described by them as a "jet dredger."

A great virtue of the design is that the vessel may be broken down into parts which can be easily transported over land or by air. This fact, in conjunction with a fairly small capital cost and low operating costs, is intended to make the machine attractive for overseas work in inaccessible areas. The dredger can be designed to operate at a depth up to 100 ft with a delivery pipe of 12 in diameter; plants to back larger delivery pipes could also be constructed if required.

As can be seen from the illustration, the dredger is controlled from a raised cockpit which has a clear view of all the equipment. In a single group are the "one-man" controls for operating the pumps, the discharge, raising and lowering the jet ladder, as well as the electric-motor capstans by which it is possible to move the vessels during dredging operations.

In the new Acrow dredger the suction is created by utilising the drop in head along a venturi tube.

The vessel that was demonstrated on the Great Ouse had the following particulars in addition to the capacity already quoted. An overall length of 56 ft, a beam of 16 ft and a draught of 3 ft; the top height above the water line was 12 ft. The piping installation gave it a maximum dredging depth of 35 ft. The power plant comprised a 160 kW diesel-electric generator driving two electric pumps each having 85 h.p. motors. Only two men—one in the cockpit and the other attending the machinery—were required for its operation. Where conditions permit, the power supply can be obtained from mains or land-based generator sets; alternatively, the pumps can be driven directly from either diesel or petrol engines. The present design is not intended for ocean-dredging operations.

The Human Element

Sop for Narcissus

The Narcissus complex in all of us is perhaps stronger than we are prepared to admit. In consequence, there is a wide interest in the definition of an engineer. A new version was given at the proceedings of the third EUSEC Conference on Engineering Education at Paris last year and has recently been published thanks to the efforts of the organising committee of the Institution of Mechanical Engineers.

The definition has a somewhat Continental flavour and rather emphasises the training and academic side of an engineer's activities. The definition as adopted by EUSEC was as follows.

" A professional engineer is competent by virtue of his fundamental education and training to apply the scientific method and outlook to the solution of problems, and to assume personal responsibility for the development and application of engineering science and techniques, especially in research, designing, manufacture, superintending and managing . . .

" His education will have been such as to make him capable of closely and continuously following all progress in his branch of engineering science by consulting newly-published work on a world-wide basis, assimilating this information and applying it independently. He must be able to make contributions to the development of engineering science and its application.

" By virtue of his education and training he will have acquired a broad and general appreciation of the engineering sciences as well as a thorough insight into the special features of his own branch . . ."

The Higher The Fewer

The National Council for Technical Awards announced last week that it has decided to create an award higher than the Diploma of Technology. It is intended that this award shall be a mark of distinction but its granting will depend on a successful candidate having pursued a course of research which keeps him in close touch with industry. The Council will establish a college of technicians, to be called the College of Technologists, and the new award will take the form of membership of this college.

The student must undertake a three years' programme of work to be carried out jointly in industry and at a technical college. The Council is much of the view that it should not create an award which divorces a man from industry. The programme of work must be approved by the employer and it must be of a kind that will make a useful contribution to technological knowledge. Supervision must be by a member of the staff of the technical college where the work is done and also by a member of the staff of the industrial organisation concerned. It follows that the award will have to be made for some time to come in co-operation with the larger concerns. Anyway, it is they who have done the pioneer work in higher technological education in recent years, so far as industry is concerned.

Application must be made to the College of Technologists through the technical college where the candidate will study.

Beyond the Academic

The vexed question of industrial training for professional engineers is due to be debated at a conference convened by the Council of the Institution of Electrical Engineers and to be held in London today. The Council expressed concern that " the plans to expand the industrial training of professional engineers have not kept pace with the Government's programme of expansion for the universities and technical colleges to increase the number of technologists."

The target of 10,000 technologists by 1970 is likely to be achieved, but the capacity to give them industrial training in the large firms, who have hitherto provided practically all the facilities available, simply does not exist. If a substantial increase is to be obtained in the number of engineers who receive adequate industrial training in electrical engineering, says the Council, some means must be found to provide such training facilities " in the smaller, and particularly in the more specialised firms in the electrical engineering industry and in those concerned in the utilisation of electrical power." As many of these firms will be unable to provide the breadth of training which is needed, some kind of co-operative effort must be arranged—hence the conference.

Another interesting sidelight on the training of technologists and the outlets which exist for their skills is provided by Albright and Wilson in a publication on *Opportunities for Chemists and Chemical Engineers.*

Old Lags at Faraday House

To the accompaniment of some exceedingly involved metaphors and suitably flippant reference to sandwich courses as the gaol-bird system, the Faraday House Old Students' Association last week heard the House reaffirm its faith in the sandwich course system. Not for nothing has it the motto of " Theory and Practice."

The declaration of faith in the system is all the more interesting at the moment in view of the recent blast from the north criticising the whole idea of the sandwich system in these days of full employment, at least as far as the west of Scotland is concerned.

It will be recalled that Faraday House announced its alternative to the Diploma course last December. This was mentioned in these notes at the time. It was announced then that the principle for the sandwich course was being re-introduced in the new Associate award. The announcement at the time said: " It is hoped that the majority of students in this course will be industrially based and arrangements are in hand to supervise their studies during the periods they are in work . . . " That is the critical issue. If economic circumstances will not force some sort of discipline then supervision from another source must take its place.

Share out

The idea of small savers buying shares gradually, and in instalments, has been current for some time. It is, indeed, the obvious practical counter to socialism. In the last week or so, there has been a sudden burst of interest in the subject. Several large concerns have published schemes for workers' share participation. " Aims for Industry " has publicised a scheme and one of the largest hire-purchase companies has announced a scheme for helping people buy shares in specific companies over a limited period of time. All this comes on top of an increased interest in the subject in the City of London which is, of course, the hub of the market.

It is by now clear that if this idea is to succeed it will have to be actively advertised among small savers whoever they may be. There is no significant demand for shares among the working classes, for example. The second question concerns matters of investment advice. If the idea is to be developed the Stock Exchange must play an active part in it. In the end, there must be a reputable professional body offering to buy and sell not only according to instructions but when its advice is taken as well. The small saver must have " spread " for his investments and he must be told why; he must know the difference between capital gains and investment for income and why they are different. In short, there are a large number of technical problems waiting solution and it will require the active participation of many investment media and organisations to launch the project successfully.

Primarily Citizens

The vital necessity of increasing the proportion of British manufactures sold in overseas markets was the theme of a paper given by Dr. Paul Chambers, of ICI, to the Industrial Co-Partnership Association at their annual luncheon. Dr. Chambers dealt with the importance of costs and of industrial efficiency, and talked at some length on the dangers that face our export industries. German competition, he said, remains very severe—not so much because German wage levels are lower than the British, but because " hours of work are rather longer, and in general you might say the German worker works hard and is prepared to co-operate to the full with his particular firm."

Dr. Chambers told his audience that one of the great advantages Britain possessed over its competitors was greater maturity in industrial relations. " We can get co-operation from the workers in this country in a way which is less fundamental, less, shall I say, satisfactory, less developed in other countries." This should enable a close co-operation to be achieved through a better understanding of the task on hand.

The Industrial Welfare Society held their annual meeting in London last week and heard Viscount Monckton, their chairman for the coming year, review the Society's progress. Looking ahead, Lord Monckton warned that the " extraordinary advances " of science and technology were becoming a challenge to people in industry. " All employees in every undertaking must be given the chance to understand and share in the opportunities and in meeting the challenge; the average man needs to feel that he belongs, that he can participate, and that his abilities and skills really count in achieving success. On the need for social welfare, he quoted Prince Philip's remark that " people are primarily citizens, not workers with a bit of spare time."

Unaccustomed as I am

The journalist on a technical journal is quite the wrong person to write an appreciation of someone's efforts to stimulate public speaking. He has sat through far too many conferences, dinners and other occasions when people have overstepped their alloted time and said even less than their audience came to hear. The standard of public speaking among British technical circles is not of the highest and, so far as the individual can judge, is always getting worse. The sight of a booklet entitled *Public Speaking is Great Fun* does not therefore enthrall us. There is hope, however, in the title. Most of the people we hear either apologise for being quite inexperienced or pray forgiveness for having to bore the audience or say outright that they are the world's worst on a platform. It crossed our mind that if a few of these people really enjoyed speaking, we might enjoy listening.

The initiative is EDA's—the British Electrical Development Association—who have published the booklet for free distribution to those who enter their 1959 public speaking competition. Doubtless a very wise move, as is the age limit imposed—no one over 35 will be able to get a word in. The three set subjects are " Making the Money Go Further "—presumably by investing it in electrical appliances—" The History of Electric Cooking," and " Lighting as a Public Amenity." If none of these appeals, any other " electrical " subject may be selected. Entries must be in by 31 December.

Companies in the News

Arrows for Canadian Defence

A spirited defence of the Arrow, Hawker Siddeley's Canadian-built fighter, was given by Mr. Crawford Gordon, at the annual meeting of A. V. Roe (Canada) in Toronto. He expressed his confidence that the Arrow and the Iroquois engine will be ordered into production when Canada's Air Defence Programme is reviewed in March.

The main reasons for this confidence added up to a strong case for manned aircraft, suggesting that the pendulum of official opinion on this matter had swung too soon and too far in the direction of remote control aircraft and missiles. "For the foreseeable future," he said, "the manned interceptor will continue to be an essential part of the North American defence system. Pilotless interceptors, such as the Bomarc, complement it but cannot effectively replace it." Mr. Gordon quoted a number of eminent military and technical authorities in his support, including Air Marshal C. R. Slemon, Deputy-Commander-in-Chief of NORAD and former Chief of Staff of the RCAF, and the Hon. James H. Douglas, Secretary of the United States Air Force. Other reasons were related to the fact that the Arrow and the Iroquois were specifically designed to fit the RCAF requirement for a manned interceptor in the time period involved, and therefore best filled these requirements. Cost also came into consideration—it would cost about $3½ million per aircraft on the basis of 100 ordered, not $9 million as most people seemed to expect.

Mr. Gordon attacked in the strongest terms what he called reliance "on a 'Maginot line' of fixed missile installations." No air defence system, he argued, could rely wholly on this kind of defence and the inherent flexibility of the manned interceptor established it in a major role which it would fill for many years to come. The news that Soviet Russia had flown a new type of long-range bomber strengthened him in his belief that ballistic missiles were unlikely to form the main weight of an attack and that it was essential to proceed "with the utmost despatch" in the Arrow and Iroquois programmes.

Indian Iron and Steel

The lack of discipline and the general low productivity of Indian workers is worrying the steel industry in India. In his annual statement the chairman of the Indian Iron and Steel Company Limited, Sir Biren Mookerjee, warned that a change is required if India's programme of industrial development is to succeed. The company's output fell by nearly 32,000 tons in the year ended 31 March and prospects are uncertain. In Sir Biren's view, the outlook was vitally affected by the attitude of the workers: "the most hazardous and a grave hindrance to industrial development is the almost daily occurrence, frequently accompanied by violence, of strikes in industry, transport, administrative and other services."

Labour-management relations in Indian industry appear to have worsened a great deal in recent months. The Communists are more active and there is undeniable hardship. Sir Biren explains that the resultant strikes have their roots in "the lack of effective measures to reduce the cost of living, to produce more food and to augment the supply of cheap cloth, housing and other indispensable necessaries of life." In anticipation of the very large increase in employment by the steel industry he considers it essential that "a uniform formula for the determination of wages for the industry as a whole" should be worked out. This will mean getting rid of a complex and illogical wage structure which is described as "a labour agitator's paradise."

Indian Iron and Steel Company suffered from interrupted and disorganised production brought about by the extension of the works. It has involved diversions of normal supply routes for raw materials, the re-organisation of the movement of supplies through the works, considerable interference with gas, water and power services, and resulted in much congestion. The first stage of the expansion, now virtually complete, will result in an increase in melting shop capacity to about 62,500 tons a month, although current output is at the rate of only 44,000 tons. Clearly, private industry and especially the section dealing with steel production, is having quite a difficult time in India's period of transition.

Fuel with Push

A new fuel is to be produced on a vast scale in the United States. A $38 million plant has been built by Callery Chemical Company—selected by the United States Navy "in the face of strenuous competition"—at Muskogee, Oklahoma. At the official opening of the plant, Rear Admiral Robert E. Dixon, chief of the Navy's Bureau of Aeronautics, expressed his confidence that the new high energy liquid fuel would "enable American air power to maintain its ascendancy."

The plant will be operated for the United States Navy and tonnage quantities are expected to be produced in 1959. It will be used in tests on various types of propulsion systems, such as turbojets and ramjets. The Navy expect these tests to determine the most practical and productive applications.

HICAL is made from four basic materials—sodium, boric acid, hydrogen and ethylene. The plant, which resembles a refinery, is composed of four processing units occuping 300 acres on a 1,300 acre site. A steam plant, nearly 25 times larger than the steam plant in a petroleum refinery of comparable size, is used to bring about reactions which create compounds with higher chemical energy. Boron (recorded as boric acid) is processed to produce diborane, the basic building block for boron-based fuels. In further processing the boron hydride is combined with carbon and hydrogen to produce HICAL. One of the unique chemical engineering achievements in the processing is a liquid distillation column which is handling both solids and liquids. Another is a $3·5 million gas plant which produces hydrogen, carbon dioxide and nitrogen.

Nucléaire

The development of nuclear powered ships is going ahead in France as fast as resources will allow. The principal company concerned, Penhoët (Compagnie Industrielle et Financière des Chantiers et Ateliers de Saint-Nazaire), are a large group of shipbuilders and nuclear engineers. One of their subsidiaries, Chantiers Réunis Loire-Normandie, was responsible for the construction of the atomic pile EL.3, put in service during the year. Research in connection with the construction of an atomic submarine continues in collaboration with the French naval authorities and preliminary studies for an atomic tanker have been completed.

Penhoët state in their annual report that they have found the task of developing satisfactory heat exchangers so complex that they have "sought the collaboration of other enterprises engaged in similar work." A group was formed last year which included Babcock and Wilcox's French company, and an agreement signed to undertake joint research and to divide manufacturing processes according to individual specialised equipment and knowledge. They have been awarded the contract for the heat exchanger for the second stage of the atomic power station construction programme (Chinon EDF2).

The development of nuclear engineering activities and the continued high level of demand for ships has led to a major programme of extensions, which include the construction of a workshop for prefabricated sections, extension of the welding facilities and the fitting of yards with the equipment needed for the construction of the largest ships. This investment should, say Penhoët, "enable the company to await confidently the time when demand for ships will revive." Seven ships were launched during the year by Chantiers de l'Atlantique (Penhoët/Loire), including a 53,000 ton tanker, and nine ships were delivered (a turnover of nearly 33,000 million French francs).

Chantiers Réunis Loire-Normandie have launched six cargo ships (ranging from 7,000 to 13,000 tons) and delivered five. The group's aviation interests, Société des Ateliers d'Aviation Louis Bréguet, were seriously affected by cuts in Government orders.

Pride of the Nation

The French take great pride in the performance of their Régie Nationale des Usines Renault. They are now the world's sixth largest car manufacturers and continue their growth at a staggering rate. Their chairman and managing director, M. Pierre Dreyfus, said in his annual statement that in 1957 the company had "continued its efforts to justify its position as the pioneer of the French motor industry." He called for a greater effort of co-operation among the leading manufacturers "to face the increased competition which would result from the establishment of the Common Market."

Renault last year produced 336,000 vehicles and exported 90,000 cars (half of these to the United States). Turnover rose to 216,000 million French francs (£191 million). This constituted a 27 per cent increase over 1956 and the company now produce 36·5 per cent of all private cars, 23·6 per cent of goods vehicles and 20·4 per cent of agricultural tractors made in France. Among the interesting information given in the annual report is the statement that last year 27·7 per cent of car sales were "to private buyers," as compared with 19·2 per cent for all other makes in the country—which suggests that at least 75 per cent of all car sales in France are to industrial or commercial interests. Renault were presumably able to do better than the rest because of the relatively low price and popularity of their Dauphine and 4 CV cars. In 1956 their sales to private buyers accounted for 24 per cent of all such sales in France.

The growth of Renault, their ability to export successfully—more so than almost any other French company—and their high profitability is quite a splendid performance by any standard. The employment of over 1,000 engineers and technicians on research suggests that they do not lag far behind any car firm in this respect. Long-term developments were centred on the production of an economic gas turbine unit.

Iron Hand in Solihull

To manufacture a machine for handling automatically pressed metal stampings and related equipment for the metal forming industry, a new manufacturing company has been established in Solihull, Warwickshire, by Sahlin Engineering Company Inc. of Birmingham, Michigan. The British company will be directed by Edward H. Rofe, formerly with the Michigan Company.

The Iron Hand, as the machine is known, is installed in 95 per cent of large stampings plants in the United States and is in use in most large vehicle manufacturing plants throughout the world. It has become necessary to manufacture in Europe because vehicle production and stampings output for other industries are rapidly approaching the United States level. The equipment would now be available for sterling and users should get improved service and delivery.

The machine is available in various standard sizes. It is self-contained, fully automatic for unloading operations and is capable of numerous adjustments which can be made quickly.

Fifth in a Series of Consolidated Reports On

RESEARCH REACTORS

By

V. S. CROCKER, B.SC., PH.D.,

of

Reactor Division,

AERE, Harwell

THE discussions on research reactors at the Geneva Conference were principally concerned with operational experiences and hence emphasised the number of research reactors now operating. The number in operation throughout the world is more than 80, the swimming-pool type being the most popular. This is not surprising for, by using forced convection cooling, fluxes in excess of 10^{13} neutrons per sq. cm per sec can be obtained.

The present types of high-flux reactors produce neutron fluxes between 1 and 5×10^{14} neutrons per sq. cm per sec. They use heavy or light water as coolant and enriched uranium, in most cases, as the fuel. It appeared that these fluxes satisfied the majority of research programmes, though there were proposals for reactors with fluxes greater than 10^{15} neutrons per sq. cm per sec. A trend that is now becoming apparent is the design of research reactors for specific research projects. This should be an improvement on the present multi-purpose research reactors, which in trying to satisfy everybody's needs, fulfil none ideally.

High Flux Reactors

A report on DIDO[1] showed the potentialities of the enriched-uranium heavy-water type reactors. For nearly two years this reactor has been operating at a maximum flux in the fuel of $\sim 1{\cdot}2 \times 10^{14}$ neutrons per sq. cm per sec. The containment and preservation of the heavy water has not proved difficult and the fuel handling problems have been much easier than anticipated, it being possible to change a complete charge of 25 fuel elements in 10 hours using one flask. The use of a flask for refuelling has always been quoted as a major disadvantage compared with a light-water reactor. The latter normally has $\sim$ 15 ft of water above the core in which fuel elements are charged visually, with special tools and no flasks. However the cost of an extra 10 to 15 ft on the height of the reactor should be compared with the cost of a flask. One important fact with regard to fuel-element changing on DIDO was given. If the fuel elements are not changed until $\sim$ 5 hours after shut-down, which is no hindrance to the shut-down programme of a research reactor, the temperature of a fuel element when removed from the heavy water and with no cooling does not exceed 450° C. This is quite a safe temperature for the fuel elements and thus cooling is not really necessary in the unload flask, though it is provided.

The reactor was originally designed for high thermal neutron fluxes but recently the damage effects in steel, graphite and other materials, caused by fast neutrons, have grown in importance and special hollow fuel elements for investigating these effects have been designed. These contain the same amount of fuel as normal elements, but have a 2¼ in internal diameter experimental hole down the centre and produce fission fluxes, estimated from measurements on the S(*np*)P reaction, approaching 5×10^{13} neutrons per sq. cm per sec. This is about an order of magnitude greater than the fast fluxes in the gas-cooled graphite-moderated power reactors. It is also thought possible that the reactor can run at 12 to 15 MW without modification. This would establish it as an extremely powerful and versatile research reactor. Finally it was emphasised that this reactor cost very little, about £2 million including the heavy water, laboratories and other ancillary items.

One development in the design of heavy-water reactors was illustrated by the MIT reactor[2] in America which has vertically acting control rods instead of the signal arms found in CP5 and DIDO. This reactor type was chosen because of some of the inherent safety advantages associated with the use of heavy water and enriched uranium, an over-riding requirement since the reactor is situated in the centre of metropolitan Boston.

Some technical and economic aspects of the MTR and ETR were described by Doan.[3] It was pointed out that the MTR had operated for more than six years with no major operational incident. Its maximum thermal flux with the present operating power of 40 MW is 5×10^{14} neutrons per sq. cm per sec. The charge for irradiations was also given, it being $55 per 10^{20} *nvt* of thermal neutrons per cu. in of reactor space. This charge is periodically reviewed and varies as the operating cost of the reactor for 1,000 MWD. A similar irradiation cost figure was expected for the ETR.

Note.—The symbols S(*np*)P represent the reaction in which a fast neutron captured in sulphur 32 causes the latter to emit a proton and become phosphorus 32; the neutron flux is deduced from the activity of the phosphorus formed. The expression *nvt* denotes the integrated neutron flux and is the product of neutron, density, neutron velocity and time of irradiation.

The operational characteristics of the MTR with a 20 per cent enriched core instead of the normal 93 per cent enriched core were also reported.[4] The fuel element construction was almost identical with the 93 per cent element, U-Al alloy being used but having 45 per cent by weight uranium instead of the normal 18 per cent. The value of the resonance escape probability taken as unity for the 93 per cent cores was estimated to be $\sim$ 0·965, thus causing a small increase in critical mass, though this apparent disadvantage, resulting in a slightly reduced thermal flux per megawatt, was compensated for by the higher ratio ($\sim$ 10 per cent) of fast to thermal flux. There is one possible advantage (with regard to safety) in the use of this type of core, in the doubling of the negative temperature coefficient of reactivity to $2{\cdot}9 \times 10^{-4}\ \delta k/k/°C$. The fuel elements behaved satisfactorily at full power and for the MTR type of research reactor it is apparent that 20 per cent and 93 per cent enriched cores can be classed as operationally equivalent. However, until an economic appraisal has been carried out bearing in mind fuel and fabrication costs, reprocessing and other requirements, it will not be clear whether the equivalence of the two types of cores will be significant.

Many details concerning the new Canadian high-flux reactor NRU, which went critical in November, 1957, were also reported,[5] its characteristic—a high flux associated with a large volume—being similar to that of NRX. In many ways it is a higher powered NRX. It runs at a power of 200 MW, which gives a maximum thermal flux of 3×10^{14} neutrons per sq. cm per sec in the moderator, and uses natural uranium as the fuel. The coolant and moderator are heavy water with a total investment of 58 tonnes, 38 tonnes of which are in the reactor vessel. The fuel consists of a number of aluminium-clad uranium plates of different widths spaced apart inside an aluminium tube. This plate-type element provides a large heat-transfer area, which is cooled by the heavy water moving at the very high rate of 33 ft per sec.

The predominating feature of the reactor is the load-unload flask which is designed for recharging the reactor while it is running at full power, thus substantially increasing the full-power

GENEVA DISTILLATE

Prolific in papers and enormous in scope, the Second International Conference on the Peaceful Uses of Atomic Energy can only assume its true significance when the information presented there has been thoroughly digested. As a stage in this process, ENGINEERING has commissioned fourteen specialists to summarise the matter of the Conference under a number of subject headings. The process may be regarded as one of distillation, with concentrated fractions drawn off at various levels. The contributors have consolidated the information published during the Conference, selecting the essentials, reconciling the submissions of different authors and countries, and tabulating the most important data. As an introduction to the series, we published on 19 September Sir John Cockcroft's overall survey of the Conference. the present series is being published at weekly intervals and will include thirteen articles in accordance with the table. The Conference was held in Geneva from 1 to 13 September.

Power Reactors		Mr. G. W. K. Ford, Research Manager, Dounreay
Research Reactors		Dr. V. S. Crocker, Reactor Division, Harwell
Thermonuclear Research:		
(Pinch Effect)		Dr. A. A. Ware, AEI Research Laboratory
(Other Devices)		Dr. R. J. Bickerton, Controlled Thermonuclear Research Division, Harwell
Propulsion	(7 November, page 600)	Mr. B. T. Price, Reactor Division, Harwell
Radiation Shielding	(31 October, page 568)	Mr. J. D. Jones, Reactor Division, Harwell
Engineering		Mr. R. P. Kinsey, Chief Engineer, Advanced Reactor Design Office, Risley
Metallurgy		Mr. L. M. Wyatt, Technical Manager, Central Technical Services, Research and Development Division, Risley
Instrumentation		Mr. R. B. Stephens, Mullard Equipment Ltd.
Nuclear Physics	(24 October, page 536)	Dr. M. J. Poole, Nuclear Physics Division, Harwell Dr. M. Sowerby, Nuclear Physics Division, Harwell
Radioactive Isotopes	(14 November, page 634)	Mr. E. R. Wiblin, Isotope Division, Harwell
Isotope Separation		Dr. H. Kronberger, Director, Research and Development, Risley
Chemistry and Processing		Dr. R. Hurst, Director, Dounreay

On the 1958 Geneva Atomic Energy Conference

operating time of the reactor and hence its overall efficiency.

The views in Fig. 1 show the size of the flask compared with the reactor. By inserting a water guide tube around the element to be unloaded the element is cooled with the reactor coolant until it is in the flask. The flask's own heavy-water cooling system then takes over. Similarly, by using the guide tube, cooling is maintained on the new fuel assembly as it is lowered into position in the operating reactor.

The unfortunate accident to NRX in 1952, which put it out of action for over a year, has influenced the design of NRU. The replacement of the reactor vessel has therefore been directly designed for.

If need be it can be lowered into a pit beneath the reactor and dissolved using caustic soda, the active effluent then being pumped away. Other features have also been incorporated which should enable repairs to be carried out with a minimum of radiation hazard to maintenance and other personnel.

The design of the instrumentation again illustrates the objective of a high operating efficiency, the equipment being so designed that repairs can be carried out without shutting down the reactor. This is achieved by having many components in triplicate or quadruplicate, and in parallel. The malfunctioning of only one line then gives an alarm but no trip.

The design and number of the horizontal beam holes provided show that much thought has been given to the needs of experimenters. In many holes, the basic requirements such as beam traps in the shielding or water-cooled "beam gates" are built into the reactor. The potential number of vertical experimental positions is very large, for any of the lattice fuel positions may be used for experimental loops, a few being designed to act as "through" vertical experimental facilities.

In answering some criticism of the NRU in respect of its high cost Dr. Laurence pointed out that the advantage of the reactor lay in its large dimensions; for example, fuel elements of 2 to 3 metres in length could be irradiated, and in its low fuel costs associated with using natural uranium.

The use of natural uranium for research reactors is a definite advantage for many countries. The first German-designed high-flux research reactor FR-2 is similar in concept to the NRU, the design being based on the desire to use natural-uranium fuel elements, which could be manufactured in Germany. India's first high-flux reactor is an improved version of the NRX and is being built in close collaboration with Canada.

The advantage, though, of using even a slight enrichment of the fuel was illustrated by the paper on EL3,[5] the new French high-flux research reactor. By using a uranium 235 concentration ($\sim$ 1·4 per cent) twice that in natural uranium, a flux of 10^{14} neutrons per sq. cm per sec is achieved with a thermal power of about 13 MW.

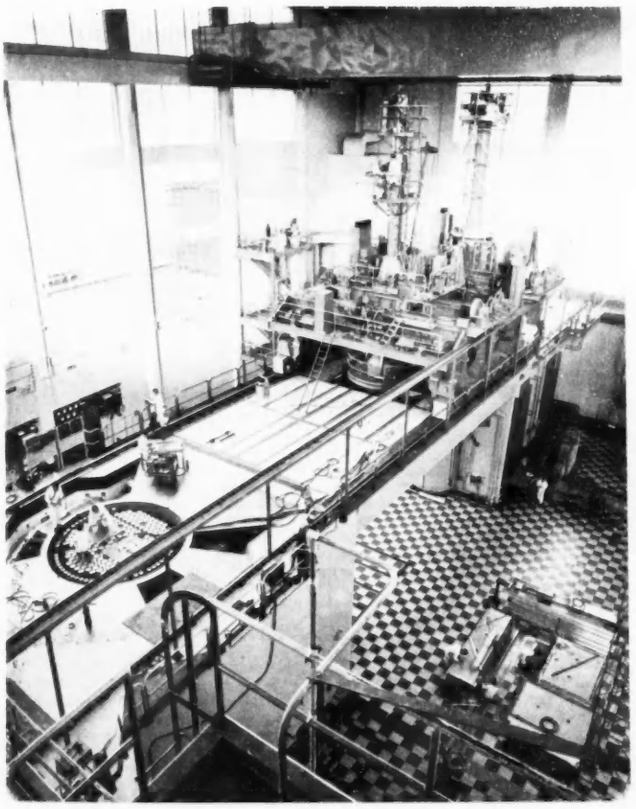
One of the most interesting reactors described at Geneva was the Belgian Materials Testing Reactor BR-2,[6] which has been designed by the Nuclear Development Corporation of America. This reactor should become critical at the end of 1959. It uses beryllium as moderator and light water as coolant and in character resembles both tank and pool type reactors. The reactor should operate at a power of 50 MW, which with a uranium 235 mass of about 4 kg, should produce a maximum thermal flux in the fuel of 6×10^{14} neutrons per sq. cm per sec.

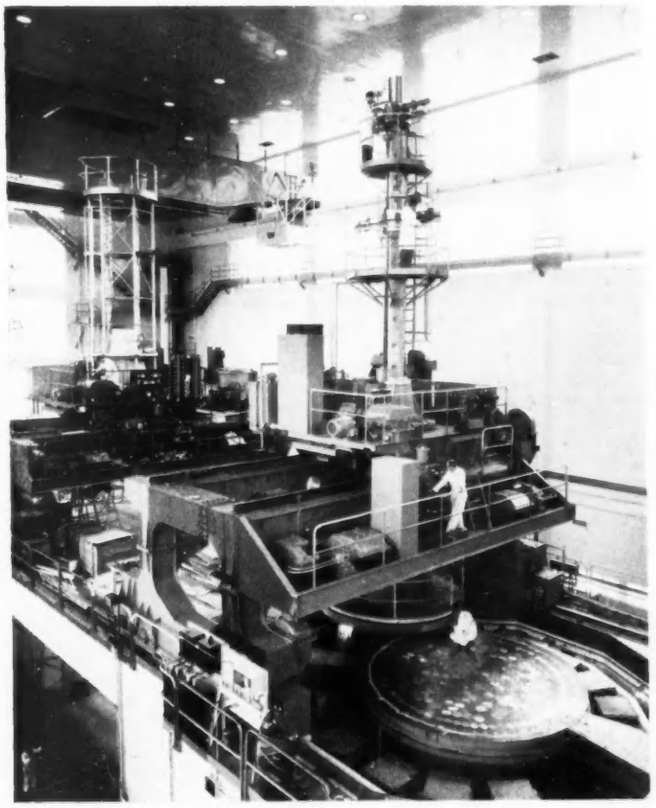
In the paper on the reactor many of the advantages and disadvantages of light-water and heavy-water reactors are discussed and some of the conclusions drawn will surely be debated for some considerable time. One of the primary disadvantages of light-water reactors is the compactness of the core, which makes the changing and manipulating of fuel elements very difficult. This has been overcome by having a skewed arrangement of the core. The fuel elements are in long tubes which are inclined at an angle so that they become generators of a hyperboloid of revolution. Fig. 2 shows the arrangement of the fuel tubes, the core itself being in the narrow "waisted" section. No element or experimental hole is inclined at an angle greater than 11° to the vertical but this small angle combined with long fuel channels gives a considerable amount of room at the top of the reactor. The fuel is in a beryllium matrix and surrounds a large 8-in diameter central facility. Each fuel element, which contains 250 gm of uranium 235 as U-Al alloy, has an active length of 30 in and consists of an assembly of up to six concentric tubes. The central cylindrical space in each fuel element can be used as an irradiation position and can be enlarged, if necessary, by removing some of the inner fuel cylinders.

The whole reactor including its pressure vessel is in a large pool of water. The pressure vessel has its own independent closed-circuit cooling system through external heat exchangers and the pool has a separate cooling system. However in cases of emergency the primary coolant can be connected directly to the pool to maintain water level.

Two other sections of the pool house a gamma irradiation facility and a core mock-up facility, the latter being almost a low power ($\sim$ 50 kW) replica of the main reactor core and

Fig. 1 Two views of the Canadian NRU reactor showing the fuel-element charging machine.





Continuing Research Reactors

experimental facilities. This mock-up facility is thought to be essential as there are many possible positions for the fuel and control rods which can radically alter the excess reactivity and flux distributions.

The overall impression given by the BR-2 is that no expense has been spared and that a great amount of attention has been given to details. Its operational characteristics and performance will be followed with interest.

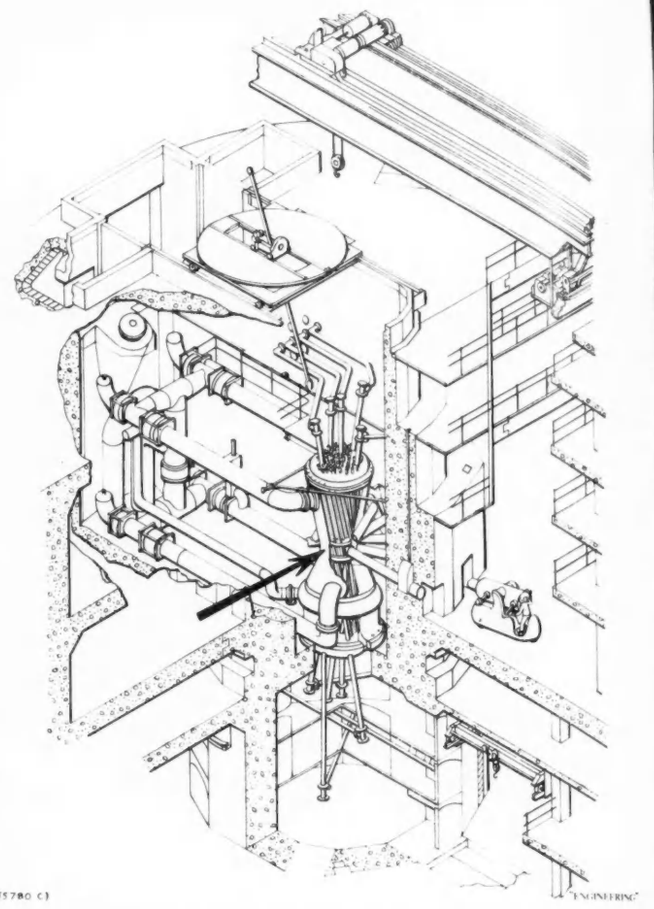


Fig. 2 The Belgian materials and engineering test reactor BR-2. The arrow points to the narrow waisted section where the core is located.

Proposed Reactors

The fluxes attainable in BR-2 are probably approaching the limit with conventional systems using water coolant and uranium-aluminium alloy elements. Fortunately these fluxes should be adequate for experiments with fuel-element loops, components and other items in the power producing reactors of the near future. However, higher fluxes are always desirable and there has been a proposal in America for a reactor which is designed principally for basic research. In endeavouring to achieve peak thermal fluxes with a minimum power output and with regard to current practice many ingenious designs have been considered. The proposal is based on the principle of the flux-trap type of reactor which has been suggested in many reports. By stipulating that the reactor should be designed for basic research the need for large experimental facilities is avoided, experiments mostly involve small sample irradiation or the extraction of neutron beams.

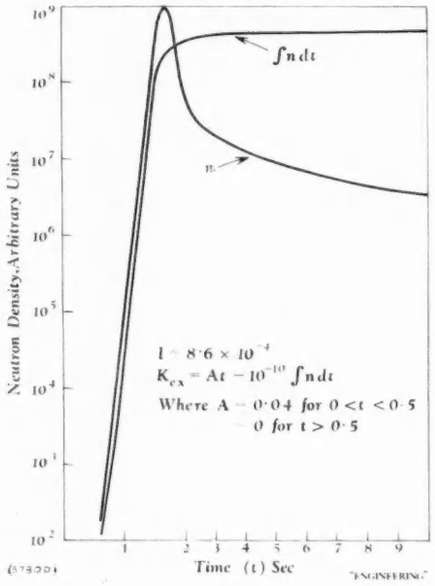
The Mighty Mouse reactor, as the proposal is named,[8] is a heavy-water cooled and moderated reactor designed to operate at 250 MW, with an appreciable zone of neutron flux over 10^{15} neutrons per sq. cm per sec. The core is annular in shape with 12 in internal diameter, in the centre of which is located a $1\frac{1}{2}$ in diameter thimble. The flux in this thimble, due to the build-up of thermal neutrons by the slowing down of the intense fast flux, is a maximum (about 5×10^{15} neutrons per sq. cm per sec). There are also numerous horizontal and vertical experimental holes in the outer reflector.

The fuel elements are groups of $\frac{3}{8}$ in outside diameter tubes of magnesium, each tube containing 1 gm of uranium 235 in the magnesium matrix. Use is made of space provided by the internal thermal column for changing fuel elements, the fuel being kept constantly under heavy water and finally placed in a heavy-water storage tank beneath the reactor.

The reactor is controlled by a combination of two systems, one is mechanical, the other fluid, both being located in radial slots in the core. The mechanical system is for regulation and safety, the other for shim control. The advantage of fluid poisoning is that the poison is added uniformly along the full height of the fuel, thus eliminating the fluctuating axial flux depressions which result from movable control rods. Boron trifluoride (BF_3) is the preferred fluid, control being obtained by varying the pressure and hence the poison density.

The types of experiments that can be done are those involving multiple neutron capture. The production of these high mass number isotopes increases rapidly with flux. The intense neutron beams would allow diffraction experiments to be done with very small powdered samples and much existing data could be improved—for example, the detailed properties of the decay process of the neutron can be studied.

Fig. 3 Neutron density plotted against time for typical exponential transient: characteristic curves for TREAT, an American pulsed graphite moderated reactor for kinetic experiments.



Research into the safety of reactors is a vital part of any reactor research programme. To obtain information on the behaviour of fuel elements and components of a reactor during a fast transient a special reactor is being built in America.[9] It is called TREAT and is a pulsed graphite-moderated reactor. A similar reactor is being built in Russia. TREAT is designed primarily for fast-neutron safety studies, but should be equally well suited to other safety studies such as metal-water reactions or reactor fuse testing. The reactor is different from BORAX or SPERT in that it is not a safety evaluation of a reactor concept but a versatile transient irradiation facility.

TREAT is designed to operate steadily at a power of 100 kW, the transient generally being initiated from that power. The core of the reactor is graphite moderated, and is fuelled with a dispersion of highly enriched uranium (as oxide or carbide) in a graphite matrix, the total mass of uranium 235 being ~ 11·2 kg. In addition to its moderating properties the graphite serves two other vital purposes. Firstly it acts as a massive heat sink, absorbing the energy generated in the micron-size uranium-oxide particles more rapidly than a conventional cooling system. Secondly, on heating, the graphite in turn raises the energy of the " thermal neutrons " thus increasing their leakage probability and so generating a large negative temperature coefficient. The average temperature rise in the graphite should be ~ 235° C and the temperature coefficient $-1{\cdot}8 \times 10^{-4}$ $\delta k/k/°C$. This built-in temperature coefficient will automatically terminate the power excursion without recourse to control rods or other means.

The reactor is controlled using 24 boron carbide (B_4C) control rods which control in all about 47 per cent reactivity. The rods are actuated and supported from below and by using pneumatic accelerators extremely fast removal times should be possible. Present experiments indicate about 100 milliseconds for a travel of 4 ft.

Preliminary studies have been carried out for exponential as well as flat-top power transients. The neutron density $n(t)$, $\int n(t)dt$ and total excess reactivity functions of time for an exponential are shown in Figs. 3 and 4. The transient is initiated by a steady insertion of 2 per cent excess reactivity in 0·5 sec and is terminated by the temperature coefficient. A mean neutron lifetime of $8{\cdot}6 \times 10^{-4}$ sec was used, which resulted in a prompt period of 40 milliseconds. The maximum neutron density attained corresponds to a flux of about 10^{15} neutrons per sq. cm per sec while the total energy release corresponds to 1,000 MW sec.

Empty fuel positions (4 in square by 24 in long) provide most of the experimental hole positions. Some of these have continuations to the sub-pile room. This size of hole should be large enough to accommodate a variety of loops for safety experiments.

The reactor appears to have two limitations if used for tests on fast reactor components. The mean neutron lifetime is much longer

(~ 10^4 times) than that in a fast reactor and thus the periods attainable cannot approach those produced by excursions above prompt critical in a fast reactor. Secondly, TREAT is a thermal reactor and large flux depressions could occur in fast-reactor type fuel elements. This can be partially overcome by reducing the enrichment of the fuel specimen and by having exceptionally large integrated neutron doses, which cause meltdown even when using natural uranium samples. This form of reactor should prove invaluable for many safety studies for all types of reactors.

The possibility of maintaining a sample in the peak flux for longer periods was discussed. This might be accomplished by a line of cores, the sample being synchronised with the removal of the control rods from the line of cores, such that it rides the crest of the power wave. The inevitable proposal was then made of an annulus of such cores so that the sample might be positioned indefinitely in the peak flux!

Russian Reactors

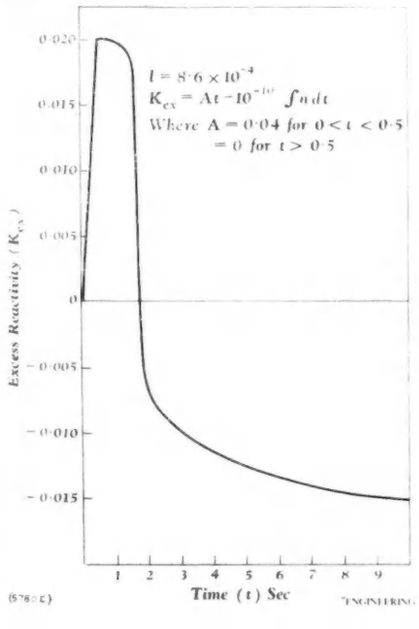
In Russia much effort has been spent not only on building new research reactors but on reconstructing their existing ones.[10] Four of their reactors have had their operating powers, and hence neutron fluxes, substantially increased. For instance the heavy-water reactor TR has almost been completely rebuilt and now operates at 2·5 MW ($2{\cdot}5 \times 10^{13}$ neutrons per sq. cm per sec) instead of 500 kW. Only the graphite shield and biological reflectors were retained, the rest of the reactor being renewed. The power of RPT has been doubled to 20 MW ($1{\cdot}8 \times 10^{14}$ neutrons per sq. cm per sec) principally by using improved fuel elements containing 90 per cent enriched fuel. Thus with a moderate financial outlay the performances of many of their reactors have been increased to make them extremely useful medium-high flux research reactors.

Two new research reactors with maximum fluxes of ~ 10^{14} neutrons per sq. cm per sec have been designed. These are particularly interesting for they have been designed with a specific kind of research in view. WWR-Z is intended for radiochemical research. Arrangements have been made for installing gas or liquid loops which can produce, outside the reactor intense neutron-free radiation fields. As an example an indium loop operating at 200° C is being considered. This of course is only one way of obtaining neutron free gamma-radiation fields, the use of spent fuel elements, accelerators and so on being other methods. However, it does show that one of the possible techniques is being studied under carefully planned conditions. The other new reactor WWR-M has been designed for basic research studies and the production of high specific activity isotopes.

At the Conference, Feinberg reported that a 50 MW reactor was being constructed in Russia to produce transuranic elements. The reactor is similar in principle to the Mighty Mouse having a flux trap at its centre, but the core is an intermediate reactor and thus generates a very high fast flux. Light water is used for the central flux trap and for the coolant, whilst the reflector is composed of beryllium. The fuel elements contain 90 per cent enriched uranium, as uranium dioxide (UO_2), and are nickel clad. It is hoped to achieve a flux of 3×10^{15} neutrons per sq. cm per sec at the centre.

There thus appears to be a trend in Russia to construct reactors for separate fields of research instead of having multipurpose reactors which endeavour to incorporate the needs of all the sciences. One interesting feature of the Russian research reactors is the use of elements composed of UO_2 in an aluminium matrix instead of uranium aluminium alloy which appears to be preferred in the United States and United Kingdom. There is probably little difference in the performance of the fuel elements, though it is possible that a higher uranium density can be obtained by using UO_2.

Fig. 4 Excess reactivity in terms of time for typical reactor experiment using the pulsed reactor TREAT.



Atomic Review

Cross Section

REACTORS and reactor control: Chapel Cross reactor critical—Site inquiry for Dungeness—French discontinue submarine reactor—Prototype of United States surface-ship reactor starts up—Tenders for study of three reactor systems in US—America investigates industrial participation in atomic energy work—America and the Six sign Euratom agreement—equipment for reactor control and simulation. Applying radition to coal processing. Notes and News.

Chapel Cross Starts Up

No. 1 reactor at the Chapel Cross power and plutonium plant, near Annan, Dumfriesshire, has begun working at low power. It should start supplying its full power of 50 MW to the grid early next year. Each of the plant's four reactors are to have a similar capacity, and should all be operating by the end of 1959. The station will resemble that at Calder Hall, three reactors of which are now working. The Chapel Cross plant is shown in page 666.

Dungeness Inquiry

The Minister of Power has decided to hold a public inquiry under the provisions of the Electricity Act, 1957, into the proposal by the Central Electricity Generating Board to build a nuclear power station at Dungeness in Kent. It will be held at Lydd on 16 December, and subsequent days if necessary.

French Submarine Reactor

It has been reported that problems have risen in connection with the power unit for the French nuclear-powered submarine Q 244, and work is therefore said to have been suspended. The reactor was to have operated on natural uranium, but now that enriched uranium may be available from the United States, together with design data, the French naval authorities have decided to discontinue work on the native project.

Prototype Reactor for Naval Surface Vessels

The first of the two nuclear reactors of the United States land-based prototype power plant for large naval surface ships achieved criticality on 21 October. The plant, located at the Naval Reactor Facility, Idaho Falls, Idaho, is the prototype for two of the United States Navy's nuclear powered ships currently under construction. These are the guided-missile cruiser, USS Long Beach, being built by the Bethlehem Shipbuilding Company, Quincy, Massachusetts, and the aircraft carrier, USS Enterprise, being built by the Newport News Shipbuilding and Dry Dock Company, Newport News, Virginia. The prototype power plant was designed and developed by the Westinghouse Electric Corporation at the Commission's Bettis Plant, Pittsburgh, Pa., in co-operation with, and under the technical direction of, the USAEC.

Proposals for Three Reactor Concepts

The USAEC have received 86 proposals from 32 architect-engineering firms for preliminary studies and estimates for three reactor concepts: boiling-water reactor—30 proposals; pressurised-water reactor—26 proposals; and organic-cooled reactor—30 proposals.

Census of US Industrial Participation

The Bureau of Census, United States Department of Commerce, with the co-operation of the United States Atomic Energy Commission, sent out questionnaires during October to collect statistical information from private atomic energy manufacturers and processors to determine the extent of United States industrial participation in the programme for the peaceful uses of atomic energy.

Euratom-US Agreement Signed

The six countries of Euratom and the United States have signed the agreement (reported in Atomic Review last 4 July) whereby the United States will build during the next five years a series of power reactors with a total electrical capacity of 1,000 MW.

Burst Slug Detection

Marconi Instruments Limited are developing a faulty fuel element detection system for the nuclear power station under construction at Hinkley Point in Somerset. The Marconi ratemeter TF 1292 has been developed for this system. The equipment includes a panel incorporating the new Marconi count analyser TF 1253. This unit will compare the ratemeter output with the preset reference level and initiate alarms if the value is exceeded. In the lower portion of the rack are the scanning and synchronising components. An electrically operated typewriter is mounted on the top of its driving unit which converts the analogue (voltage) output of the ratemeter into digital form. It is used for alarm and routine tabulation.

Data Processing for a Reactor

Panellit Limited (a member of the Elliott-Automation Group) have built a new form of data processing and information system to the

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[9] G. A. Freund *et al*., TREAT, A Pulsed-Graphite Moderated Reactor for Kinetic Experiments. Geneva Conference P1848 USA (1958).
[10] V. V. Goncharov *et al*., Some New and Reconstructed Research Thermal Reactors. Geneva Conference P2185 USSR (1958).

Continuing Atomic Review

instructions of the United Kingdom Atomic Energy Authority for application to a reactor. The equipment is similar in conception to the Panelliott 609 system which employs an Elliott 802 computer. In this application it is required to scan at high speed 600 points registering variation in temperature level and rates of change of temperature detected by thermocouples. It was a requirement of the UKAEA that the design should embrace all techniques which would ensure maximum on-line availability and to this end the design incorporates many unique features.

The only moving parts in the entire system (excluding the output printer) are the input relays which connect the selected thermocouples, and careful thought was given to the choice of suitable apparatus. After investigation into the problem the Clare Mercury-wetted relay was selected as possessing suitable reliability. These relays have been tested to 3×10^9 operation without failure and have a minimum of noise, a factor essential in a system capable of a high degree of discrimination. The input signals for the thermocouples are fed to a high-stability Offner differentially connected amplifier, and from this point to an electronic analogue-to-digital converter before being passed into the computer. To allow any point to be recorded in analogue form on potentiometric recorders a jack panel has been included enabling any 12 points to be connected to the recorders. The equipment has been designed to provide a complete record of 600 points scanned in two minutes for both level and rate of change, and the facilities include a history of the last five scanning operations. Due to the flexibility of the system there are many additional facilities which can be brought into operation by the simple task of changing the computer programme.

Neutron Detectors for Reactor Control

Safe and more accurate control of nuclear reactors is made possible as a result of two neutron detectors, capable of operating efficiently at temperatures up to approximately 200° C, which have been developed by Plessey Nucleonics Limited. They are the PNI1025, a three-electrode ionisation chamber incorporating gamma compensation, and the PNI1026, a two-electrode version. Both detectors are capable of being operated under plant conditions, at the ambient temperatures of the core or shielding, for long periods without attention. They are said to have the minimum possible gamma sensitivity consistent with adequate neutron sensitivity and after operation at high neutron fluxes provide the minimum possible current from residual activities in their structural materials.

Major components of both detectors are of high purity aluminium. Internal insulators and electrode supports are of alumina and the vacuum lead-through seals are of the ceramic-to-metal bonded type. This form of construction provides for rigid mounting of the electrode assembly quite independent of the vacuum seals and cable terminations. The chambers have a substantial aluminium baseplate which shrouds the vacuum seals and carries the cable terminations. The baseplate contains stainless-steel wire inserts which provide the chambers with substantial support. Completed detectors are tested before filling to an internal pressure of 100 lb per sq. in. Neutron-sensitive coatings of either natural or enriched boron can be provided. The chambers are normally filled with hydrogen at pressures of 25, 75, or 225 cm Hg, but alternative fillings can be supplied if required.

Although the chambers can be operated at temperatures up to approximately 200° C the precise upper limit depends on the lower limit of current to be measured and the filling pressure. Polythene insulated sealed terminations designed to take similarly insulated and sheathed cables are fitted for normal and moderate fluxes and temperatures.

Simulator for CEGB

Elliott Brothers (London) Limited, a member of the Elliott-Automation Group, have been awarded a contract by the Central Electricity Generating Board for the design and manufacture of a nuclear power station simulator. The simulator will be used for training operators for the Berkeley and Bradwell Power Stations and for subsequent stations of similar type. It consists in effect of a replica of the main control desk and will simulate not only the reactor itself but blowers, heat exchangers, and other items. The simulator will be able to reproduce abnormal working conditions, a facility which will be under the control of an instructor provided with a special panel out of sight of the trainee. The simulator is to be installed at Berkeley in the middle of 1959.

Uses of Radiation

Radiation for Coal Drilling and Gasification

Radiation methods are being used to solve a number of problems in Britain's scheme for underground gasification of coal. Humphreys and Glasgow Limited, of London who are building the pilot plant for the National Coal Board at Newman Spinney near Chesterfield have used radioactivity successfully in four ways.

Tracer Tests.—The radioisotope krypton 85 has been injected as a tracer gas into an airstream to determine the position of leakage in underground piping. It has similarly been used to indicate the rate at which coal is being gasified underground, the occurrence of subsidence of roofing or the merging of two or more borehole fires. During and after gasification, gas returns to the surface along the same shaft; monitoring begins immediately at the surface for the return of radioactive gas. If there is no leak radioactivity is monitored as a single pulse, but if a leakage exists, a small quantity of radioactivity is monitored ahead of the main pulse—assuming that the leak is subsidiary to the main flow. Calculations are then made to locate the position and magnitude of leakage. In checking for subsidence, or merging of fires, monitoring is done from adjacent boreholes. Cross-flowing from one borehole to another can unbalance the flow of the gas to the surface, and early warning enables steps to be taken to restore the balance. The krypton 85 tracer technique has been developed by scientists of Humphreys and Glasgow Limited in collaboration with Isotope Division, Harwell.

Borehole Location and Intersection.—Engineers at Newman Spinney found that accurate drilling of a vertical borehole to intersect a horizontal one was difficult with available survey methods. The problem has been solved by using the radioisotope cobalt 60. A full-sized horizontal hole is drilled and a small-diameter vertical hole sunk to the expected location for intersection. If this misses, a source of gamma radiation is placed in one borehole and a counter in the other. Radiation is then transmitted through the coal barrier and measured, by comparing this value with known standards the separation can be found and intersection achieved.

Coal Sensing.—Another problem was the accurate directing of the drilling bit along the seam. Deviations due to irregular strata cause wastage in time and labour. The general layout of coal strata having previously been discovered by vertical and horizontal drilling, an instrument using radioactive cobalt and developed by the Mining Research Establishment of the National Coal Board is used to give warning if the drilling bit is in danger of leaving the coal seam. The operator can alternate his drilling with a probe of this coal-sensing instrument inserted into the borehole. When thin coal is drilled, the operator can redirect the drill before valuable coal is lost. Ultimately it is hoped to position the coal-sensing instrument, emitting gamma radiation, behind the drilling bit.

Control of Drilling Using Natural Radioactivity.—The variation in the amount of natural radioactivity occuring in different strata may be used to enable drilling to be kept on course. Clay, for example, contains up to three times more radioactivity than coal. Near the edges of the coal strata, therefore, a significant increase in radioactivity is recorded. When this occurs during directional drilling, the drill setting can then be modified to maintain the bit in the seam—an important development in underground gasification techniques, which calls for boring horizontal holes of considerable length.

Notes and News

Structural Steel Contract at Harwell

Hill and Smith Limited have been appointed by the United Kingdom Atomic Energy Authority as structural steelwork contractors at the Atomic Energy Research Establishment, Harwell, for the next two years under a term contract. The contract was awarded on the basis of an intake into Harwell of 600 tons.

Sir John Cockcroft in USSR

Sir John Cockcroft has been in the Soviet Union, where he spent about seven days on the invitation of the Academy of Sciences.

UN Conference Proceedings

The United Nations have announced that the prepublication period for the *Proceedings* of the Second UN International Conference on the Peaceful Uses of Atomic Energy, during which complete sets may be ordered at a special price, has been extended to 31 January, 1959. Until 31 January, the 33 volumes of the English edition may be ordered for US$435, £155 sterling, or 1,860 Swiss francs. The special prepublication price for the complete set represents a saving of some $70 as compared with the regular price of the set. Publication of the individual volumes has begun. *Volume* 2, *Survey of Raw Material Resources*, was published on 20 October and is now available for $18·50 or the equivalent. *Volume* 3, *Processing of Raw Materials*, a companion volume to Volume 2, will be available shortly for $15 or the equivalent. Nine other volumes of the English edition are expected to be available before the end of 1958 or early in 1959.

View of the Chapel Cross power and plutonium plant, one reactor of which is now operating.

Meeting on Food Irradiation

The Food and Agriculture Organisation of the United Nations will hold a European meeting on the use of ionising radiations for food preservation at the Cockcroft Hall, Atomic Energy Research Establishment, Harwell, Berkshire, from 17 to 21 November, 1958.

Atomfair USA

The fifth Atomfair, to be held in conjunction with the 1959 Nuclear Congress mentioned in Atomic Review last week, will take place from 5 to 10 April, 1959 in Cleveland, Ohio.

In Parliament

CASE FOR CROYDON AIRPORT

Among the shorter debates in the House of Commons last week was one on the desirability of retaining Croydon Airport, which, it was pointed out, was due to close at the end of December as the result of a decision made in 1953.

The subject was introduced by Mr. F. Beswick (Labour Co-operative), a former Parliamentary Secretary to the Ministry of Civil Aviation, who made the point that if Croydon Airport were closed, London would be one of the few capital cities of the world around which there was not a single airport available for the use of light aircraft. Within a 10-mile radius of Paris seven such airfields were available and, within a similar radius of New York, there were eleven.

Croydon Airport was bound up with the history of civil aviation in this country and the case for its retention was that there was a need for at least one airport with customs facilities, in, or conveniently near, London, such as could be used by aircraft severely restricted in size, weight, and noise-production. Such machines included club aircraft, privately-owned aircraft, the executive types now being built and developed in so many other parts of the world in increasing numbers, and, possibly, some passenger-carrying machines up to the size of the Dove and the Heron.

REASONS FOR CLOSURE

In theory at any rate, Mr. Beswick said, the Government had always accepted the contention that there was a need for such an airport and had promised an alternative when Croydon was closed. Different reasons had been advanced at different times to support the closure decision. They could be grouped into four categories: defence and security reasons, public amenities, aircraft control and safety, and economics and finance.

The security aspects were fairly well known to those who took an interest in such matters. He did not think that there was anything in the proposals for development round London which excluded the possibility, at any rate, of an extension to the life of Croydon Airport. If, on the grounds of noise and public amenity, it were argued that the use of Croydon as an airport was not possible, and it were shown to him that there was an overriding argument in that connection, he would be inclined to accept it, but that argument did not seem to be seriously put forward by the Ministry of Transport and Civil Aviation. The length of Croydon's runways, the restricted size of the aircraft, the possibility of their climbing to a reasonable height before reaching the airport's boundaries, and the increasing use of silencers, all indicated that noise itself was not an important factor.

If a convincing argument were advanced that it was not possible to retain Croydon Airport within the London control zone, owing to the control and safety problems involved, he would be inclined to accept the closure for that one reason. But that argument seemed to be brought in only as a make-weight. As to the economic aspects, it was believed by many that these formed the real explanation of the Ministry's attitude. He did not consider that a transfer to Biggin Hill was an adequate alternative.

NOISE STILL A PROBLEM

Vice-Admiral John Hughes-Hallett, Conservative member for North East Croydon, said that the Croydon members had been involved in the dispute over Croydon ever since it came to the fore about a year ago, and they had received various delegations on the subject, including representatives of Croydon Corporation, local chambers of commerce and airport users. There had been discussions with Mr. Airey Neave, the Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, and, as a result of these meetings and the correspondence that had taken place, during which the Minister had explained some of the difficulties arising, they had very reluctantly come to the conclusion that the reasons which had actuated the Government in reaching their decision were unanswerable.

Safety was a very big factor indeed. Then there was the noise problem. The airport was not in his own constituency but another Croydon member had assured him that quite an appreciable proportion of his correspondence was supplied by people complaining of the noise. On the question of finance, the Minister had given in some detail the precise conditions under which the airport would be allowed to continue in use as a private aerodrome, or, at any rate, as a useful aerodrome. Speaking subject to correction, he believed that there was nothing to prevent the local Corporation taking over the airport and running it under those limiting conditions. He suspected that, financially, it was not an attractive proposition.

Mr. Frederick Gough (Conservative), chairman of the Royal Aero Club, said that the Minister had received a deputation from the Club—"probably the father and mother of private flying." Far too little time had been given to the private flyers at Croydon to make alternative arrangements.

FUTURE OF PRIVATE FLYING

Replying for the Government, Mr. Airey Neave said that they did not rejoice at all in the closure of Croydon. The Government certainly had a very considerable duty in regard to private flying but they also had a grave responsibility for safety and air traffic control.

Rents at Croydon were uneconomically low. The total revenue from all sources for the twelve months ended 30 March, 1958, was about £84,000, compared with total outgoings of £231,000. There was not a chance of making Croydon pay without a great increase in commercial traffic. Such an increase could not be tolerated for air traffic control reasons. If an extra number of aircraft were to fly into the control area at Croydon they would interfere with the flow to and from London Airport, and, later, to and from Gatwick Airport. Movements from and into Croydon were already a serious embarrassment.

The Government were endeavouring to provide a private aviation centre in south east England. While it might be possible to place some operators at Gatwick, they still had to consider the idea that a suitable airport with international aspects for an aviation centre was the right thing for the future. So far as the clubs were concerned, all flying must cease on 31 December. Their transfer to Biggin Hill would be more speedy than the transfer of charter firms, executive flyers and business users. In their cases, Croydon could remain open for a limited period after 31 December, during which there would be a progressive rundown of operations.

BRITISH INSTITUTE OF MANAGEMENT

Grants-in-aid paid by the Government to the British Institute of Management formed the subject of questions by Mr. Austen Albu (Labour) to the President of the Board of Trade. He asked if the President could confirm that that organisation, which for the last ten years had been preaching better management and methods to British industry, had had to call in the organisation and methods department of a private firm to overhaul its own administration and structure.

Sir David Eccles replied that grants-in-aid to the Institute were £536 in 1946-47 and £15,415 in 1947-48, rising to £75,000 and £78,000, respectively, in the financial years 1950-51 and 1951-52. Thereafter, the grants had declined to £29,980 in 1956-57 and £10,000 in respect of 1958-59. No grant had been given for 1957-58. The Government were prepared, on certain conditions and subject to parliamentary approval, to make a final grant of £5,000 during the financial year 1959-60. In addition to grants-in-aid, payments totalling about £89,000 had been made to the Institute from the Government's conditional aid funds.

He agreed that the Institute had had a certain amount of internal difficulties. It was always the case that the Institute knew that the Government grants would taper off. He thought that the grants had continued rather longer than was at first intended and he hoped that the Institute would now be able to stand on its own feet.

WEIGHTS AND MEASURES LAW

Replying to questions from a number of members regarding the need for implementing the recommendations of the Hodgson Committee on Weights and Measures Legislation, which reported as long ago as 1951, Mr. John Rodgers, Parliamentary Secretary to the Board of Trade, said that the President of the Board intended to make regulations to deal with part of the field covered by the report, but a little more time would be required.

He told Mrs. H. Slater (Labour/Co-operative) that the committee's report contained many very detailed recommendations and that, in many cases, these presupposed considerable consultation. The Board had had to consult over 90 organisations and some of these consultations were still in progress. It was entirely true, he told Sir Frank Medlicott (Independent), that the trade organisations concerned had, in most cases, given a great deal of co-operation and information. He told Sir James Duncan, Bt. (National Liberal and Unionist), who said that the Angus Joint Weights and Measures Committee felt some anxiety regarding the packaging of food, measures for drink, and the tolerances for petrol pumps, that the regulations proposed would be concerned with the retail sale of food and the marking of pre-packaged foods. The regulations would not deal with petrol.

Incidentally, Mr. Rodgers, who was appointed a Minister on 23 October, was answering his first parliamentary questions and he received a number of congratulations.

CHINA NEEDS COMPUTERS

Mr. J. Rankin (Labour/Co-operative) asked the President of the Board for the reasons why there was still an embargo on the export of certain types of electronic computers and high-speed cinematographic cameras to China, Russia and other Communist countries. He said that Britain now possessed a lead of four to five years over any other nation in the manufacture of these products. Although it might be possible to keep these matters a secret now, advancing knowledge would cause them to be shared with the rest of the world eventually, with the result that, in due course, not only would the secret knowledge be lost, but also what was now a good market. Sir David Eccles answered that he could not supply the information asked for as the proceedings of the Paris Group were confidential, but that many types of computers and high-speed cameras were free from embargo. He added that Mr. Rankin might have seen references in the Press to the effect that some of these computers were needed in connection with rocket missiles.

DIPLOMA IN TECHNOLOGY

In another question, Mr. Austen Albu asked the Minister of Education how many students for the diploma in technology were works-based and how many college-based. He inquired as to the response which was being received from local education authorities to the request made to them to provide grants to students who were to be college-based and how the response which the Minister was getting from firms who were to provide the in-works training compared with the number of students who were to be college trained. Mr. Geoffrey Lloyd said that information regarding students who were works-based and college-based was not available in precise form. In general, the response he had received was good, but the larger number of students for the diploma were works-based.

Special Article

WHOLESALE COMPUTING

A WEEK from today the Electronic Computer Exhibition opens at Olympia. Many of the machines on show will not be new; many will have been on the market for over a year. The time lag is important—it is the application time.

Perhaps this aspect of the Computer Exhibition is best brought out by comparison with the Motor Show. Naturally, there will be new items of equipment at the Computer Exhibition; but whereas a car can be used straight away, it is rare, outside a mathematical laboratory, that a computer can: not until a period of application study has elapsed; a period that at present may extend over two years. Newness, novelty, more storage, a higher top speed: these are important qualities for the buyer at the Motor Show; at the Computer Exhibition they are marginal—subordinate to the question of how easily the computer will fit into the working of an organisation. The most important exhibit on many of the stands will be invisible. It will be "know-how"—how to apply a computer to the day-to-day running of an industrial firm.

Slowly the number of applications is increasing. Easiest entry for a computer into the running of a firm appears to be by way of the stores: by its use in stock control. In manufacturing firms this is only a first step, but in wholeseale-retail firms it is a major part of the business. The following paragraphs give an account of electronic calculating techniques as they are applied or about to be applied in three firms. By far the most ambitious is the installation at the Letchworth factory of the British Tabulating Machine Company Limited, where the computer is being used for production control. The application to problems of distributive trade is simpler, and the first two examples are of this type: installations to be used by the Boots Pure Drug Company Limited and Kardomah Limited. The latter installation does not in fact use a full-scale computer, but is described in detail as it illustrates well the problems of stock control. All three companies are using electronic techniques to enable a more efficient ordering of stock: BTM, for example, hope to reduce their stock holdings by 50 per cent and release capital for more productive work.

The actual introduction of electronic computing techniques into the running of an industrial firm requires an operations research team. The Boots installation, for example, will have involved 15 man-years of preparation by the time the computer is delivered. Mr. D. S. Greensmith, general office manager of the company, stressed the importance of the preparatory period, when speaking at a recent Press conference. He emphasised that the company found the delay of two or more years between the first order for a computer and its delivery a positive advantage. He believed that no company could work out the proper re-organisation of its business administration in anything less than that period, nor could they train the specialist staff required to operate it, feelings which are shared by BTM who required a similar interval for incorporation of their computer.

Capacity for Data

The Boots installation is to be in two main parts: an analysis of financial transactions carried out by the shop cash registers; and control of stock. Little has been released about the first, other than the fact that a Solartron Electronic Reading Automaton will be used to scan the till rolls. For the second, an EMIDEC computer will be installed by the summer of next year. It will maintain a perpetual inventory of all the 60,000 lines stocked by Boots warehouses, and will show how stocks of each item fluctuate with orders from the branches. By analysing the fluctuations it is hoped that eventually the production scheduling of certain basic items made in Boots own factories will be planned by computer.

A diagram of the overall organisation of the company is shown in Fig. 4, while the functioning of the data processing centre is indicated in Fig. 3. The total input derives from 70,000,000 items ordered per year at 1,300 shops, the peak load reaching some 300,000 items per day. In coding the items for processing, about four letters and two figures are used for each item. Thus the system has to handle an input of 2,100,000 characters on some days.

The printed output includes despatch notes (invoices), out-of-stock reports, "to follow" invoices (goods not supplied), theoretical stock reports, and error reports (invalid codes). With one printed line allowed per item, the main output of the centre involves 350,000 lines of print per day. The computer will automatically sort the orders into the sequence in which they are stocked in the warehouse, thus making the task of assembling them for despatch easier. It will also print out a duplicate order/invoice, one copy of which will be supplied to the branch manager to compare movements of stock with the level of his weekly takings.

Order processing is carried out daily, and branch accounts monthly. Reports of items out of stock or items in which the stock level is critical are made daily. Re-ordering is also carried out daily. In this way the organisation can supply the buying offices with stock information in the most useful form; and branches can be informed of consignment details when or before the goods arrive. And a control mechanism is provided for reducing the stock levels in the warehouse.

Financial Control

Kardomah Limited also have to control fast moving stocks. They operate as retailers and wholesalers: tea, coffee and many other commodities, totalling some 3,000 different items, have to be delivered to Kardomah cafés and customers. The organisation is similar to that shown in Fig. 4, and the problems are similar: fluctuating demands must be met promptly, while at the same time stocks must be kept to a minimum.

To meet this situation, the company are installing an IBM 421 accounting machine and an IBM 604 electronic calculator, together with certain items of ancillary equipment. The installation will be producing invoices, calculating average unit prices and posting stock ledgers, and preparing financial and other

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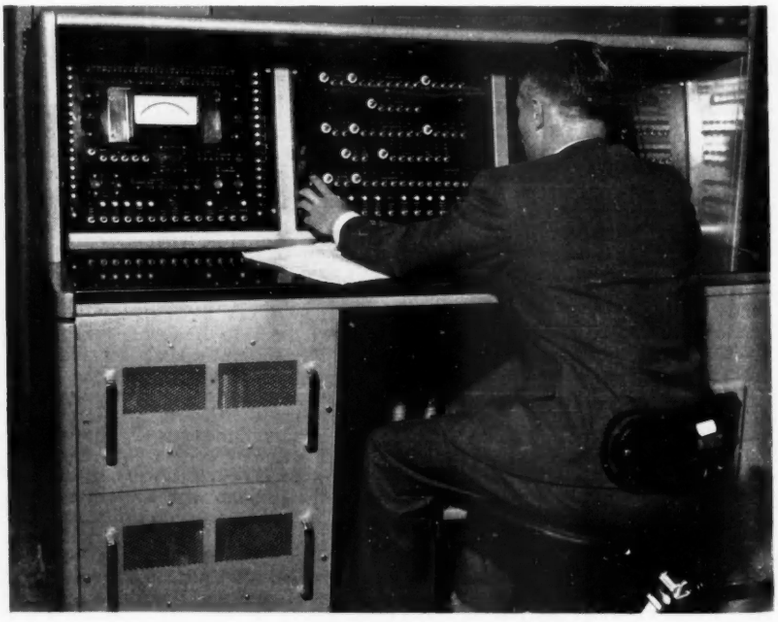


Figs. 1 and 2 The computer establishes a feedback and control link between production at Letchworth show the two ends of the link: the central control console of the

accounting analyses. It will also produce a daily stock availability report and "action" documents for controlling stocks, issues and orders, on a daily basis. At times the two main items of equipment will be used separately, but to produce the stock availability report, the 421 and 604 will be linked together. In this way the 421/604 electronic calculating group is formed, which possesses many of the characteristics normally associated with digital computers.

The 421 accounting machine is used for printing reports of all kinds. In one minute it can accept 150 cards and print 150 lines. The 604 electronic calculator has a wired programme panel of 70 steps, with optional programme repeat. Card feeding can be automatically delayed to allow the completion of long calculations, and programmes can be varied in the same run for cards of different categories. The machine may be used with an IBM 521 punching unit alone, if punched card input and output is required, or if a printed output is also required, the IBM 421 is connected up with the other two machines. All three are shown in Fig. 5.

The stock availability report is produced from punched cards fed into the system. The cards, which are described in more detail below, are fed in at a speed of 150 per minute, and a commodity description and up-to-date stock position is printed for every item stocked. Included in the information printed for each item are the following:—

Stock in hand (old balance plus receipts minus issues)
Requirements
Unallocated stock
On order
Total stock unallocated and on order
Average daily requirements
Number of days stock in hand
Percentage variations of current requirements from average
Re-order level.

In order to keep stocks to a minimum, the re-order levels of items that experience fluctuating demands should be no greater than the current demands warrant. The re-order level in this case is expressed as

2 × lead time × average daily requirements,

where lead time is equal to the number of days that elapse between placing an order and receiving the goods. The average daily requirement is a calculated quantity that is arrived at as follows.

If A = Average daily requirement, not including today's requirement.
R = Today's requirement.
P = Averaging period.
D_c = Current working day number
and D_p = Previous working day number when the last stores issue note was printed.

Then the new average daily requirement is

$$\frac{A\,[P - (D_c - D_p)] + R}{P}$$

This number will follow a fluctuation in demand more rapidly than would a true arithmetic average. The speed with which it follows current trends is inversely proportional to the size of P, which is determined by the buyer's knowledge of the conditions affecting the supply and demand of a particular commodity.

The input cards that are fed into the system to produce the stock availability report are divided into balance cards and transaction cards. The balance cards are produced as a summary on the previous day's stock ledger run, and consist of the actual balance cards and the order balance cards. The transaction cards up-date the actual balance and the order balance and show the requirements from branches and customers. They are detailed below.

Description Summary Card—bears constant data such as description, lead time factor, averaging period, etc., and also contains the up-dated average daily requirement.
Order Issued Card—orders placed on outside suppliers.
Order Received Card—order fulfilled by outside supplier.
Goods Received Card—goods received from outside supplier.
Production Card—goods received from production.
Adjustment Card—stock adjustments such as transfers and amendments.
Purchase/Production Summary Card—represents an outstanding purchase/production advice for which a copy order has not been received.
Issue Card—requirements from branches and customers are punched into these cards. When the stock is issued they are punched again.

Two independently controlled form-feed devices fitted to the 421 allow the printing of both the stock availability report and, according to the conditions set up during the 604 programme, the printing of stores issue notes and purchase/production advices. When requirements cards are among the cards for a particular commodity group, a stores issue note is printed. If as a result of requirements, the unallocated stock plus stock on order falls below the re-order level, a purchase/production advice is also printed.

The stores issue note is the authorisation to the stores to make the required goods available to the despatch department. The total quantity required is converted during the 604 programme into the number of packs and remnants, and printed in this form to simplify the storekeeper's work. Should the stocks of a commodity be inadequate to meet the demands the word "stop" is printed in place of the quantity. If a stop note is printed, no items of that particular stock are issued except on authorisation by the sales department, who assess priorities and allocations.

When the total requirements for a commodity reduce the unallocated stock plus the on-order quantity to below the re-order level, a purchase/production advice is printed. A production advice is sent to the production scheduler, a purchase advice is sent to the buyers to inform them that a further order must be placed; it also tells them the number of the last order placed, the last order price, and the minimum re-order quantity. The last item is calculated during the 604 programme by subtracting the unallocated stock and the on-order balance from 1·5 times the re-order level. It serves as a guide to the buyer, who examines the latest stock availability report and takes other factors, such as the state of the market, into account when placing the order. In this way the integrated machine accounting system not only controls all aspects of financial accounting but also provides the comprehensive information on which management decisions are based.

Production Control

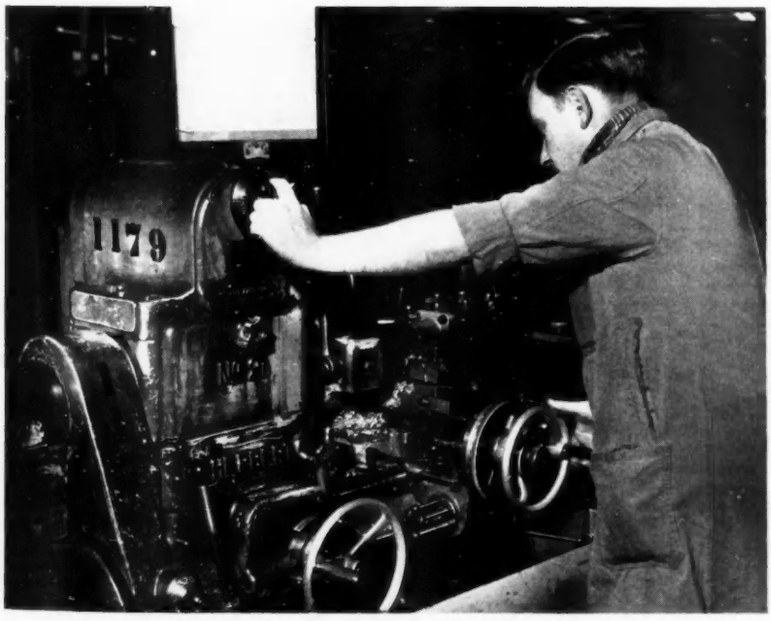
The British Tabulating Machine Company Limited are using a computer for production control. In December, 1956, the directors of the company decided that an order should be placed for a HEC type 1201 computer for use in this way. At the start, a team was appointed, consisting of an outside consultant of wide experience in production management and one representative from each of the company's production and sales divisions. A computer production control research section was then set up under the general direction of the team. Apart from ancillary staff, the section comprises an experienced production engineer recruited from outside, who acts as head of the section, a senior systems engineer, a systems engineer, two programmers, and an administrative officer to look after the general running of the section.

BTM has three main factories, and although the scheme is eventually intended for all three, the smallest was chosen as a guinea pig. Situated in Letchworth, it is referred to as number 1B and has a total personnel of about 500, 100 of whom are staff, supervisory and otherwise. The factory is divided as follows.

(1) *Machine Shop*—with range of autos, capstans, drills, presses, and one or two special purpose machines.
(2) *Assembly Shop*—with sections for coil winding, relay assembly, cable harness control panel assembly, and brush assembly.
(3) *Special Order Department*—with grinders, lathes, and jig borer.
(4) *Inspection.*
(5) *Stores.*

There is no provision for special processing such as heat treatment or paint spraying.

The output of the Letchworth factory, number 1B divides naturally into groups containing a number of different types of end products, as indicated in the table below; special orders and



management and the shop floor. These two illustrations of the BTM installation computer and an operator working from a computer production operation card.

Continuing Wholesale Computing

piece parts for other factories form a variable quantity.

Number of Types of End Product in Each Group

Cables ..	320	Brushes ..	24
Coils ..	120	Control panels	20
Relays ..	120	Plugwires ..	11

Thus, about 600 different end products are being made by the factory, but over half of them are cable assemblies, which cannot be considered as complex in the sense of embodying a large number of piece parts.

Programme Breakdown

Production control in the factory falls under four headings: programme breakdown, plant loading, progress control, and stores control. The first stage of programme breakdown consists of procuring information as to what is wanted—by the sales organisation, the spares supply organisation, and the research organisation. The second stage consists in determining what materials, piece parts, and assemblies have to be made or bought to supply the demand.

The starting point of calculation is an agreed consolidated programme setting out the requirements for a 12 month period starting from a specified date. Of the requirements, the first four months are treated as positive and firm: those for the subsequent eight months as tentative and subject to revision. Programme revisions occur three times a year.

The procedure followed is to punch up a card for each end product in the programme, identifying the product and stating the number of units required in each of a pre-determined number of periods of time ahead. In addition a master file is held of cards that indicate all the end products in which a given item is used. By processing the two sets of cards in the computer, the total requirements for each item by part number is produced. This is the gross requirement: subtraction of the number of items already in stock gives the net requirement.

Plant Loading

Plant loading involves producing information for the shop floor, setting out operations to be performed, order of performance, and machines and other facilities to be used. The net requirement card is the starting point. In addition, the production staff need to know what operations are required for each item. For this purpose, a file of operations master cards, set up from existing operation records, is maintained. Each of the cards indicates time in hours, to the nearest tenth, required to set-up for the operation; allowed time for one off; and interval time between each operation and the next. Summing the three gives the operation time.

The question then arises as to when in the production cycle the operation is to be performed. As factory 1B works on a 10 week production cycle, the problem solved on the computer is the time at which any part must exist in order to be available for use in the next production stage requiring it. For example, if final assembly were to take a week, then all items required for final assembly must come into existence 10 − 1 = 9 weeks from the beginning of the production period. In this way a series of hypothetical starting dates for all operations is arrived at.

To bring the solution to practical terms, a third file of punched cards is needed; in these overall capacity, in terms of machine tool groups, is recorded—together with details of existing loads. The total load (existing and proposed) for each machine tool group during a production cycle can be computed: the calculation will quickly show if any group is going to be overloaded. Should this occur, it can be dealt with—generally by overtime or perhaps by subcontracting outside. Prolonged overload would show the need for added capacity.

The broad picture having been established, the detailed plant loading is carried out at closer and more frequent intervals. Starting at any given week in the production cycle—the starting point being defined by the latest completion date for a particular part—and taking advantage of the discriminatory facilities offered by the computer to test load requirements against available capacity, one works backwards week by week until the total load is successfully absorbed. It is possible to disregard particular weeks of the cycle if time available on a particular machine is insufficient to make it worth while to load part of the requirement during that week, for example, if set-up would be uneconomic.

The output produced by the computer at the plant loading stage comprises:—

(*a*) Load statement, showing the load on different shops, sections, and machines week by week over the production period—to guide the production management, not for issue to the shops.

(*b*) Statement of requirements of jigs, tools, fixtures, and other facilities for the carrying out of each operation—in other words a subsidiary load statement covering only these facilities.

(*c*) Operation job cards—for each operation on each part or assembly.

The load statement and the operation job cards set out the long term strategy. This may be modified: for example, owing to a crash programme, or to alterations to a specification, or to the re-introduction of items of which a short fall has been reported.

The short term tactics, defining to the shops what they do each week, are presented to them by the issue of:—

(*a*) That section of the load statement covering only work to be done next week. This is issued one week before the work is actually to be done.

(*b*) Operation job cards covering all jobs to be done next week. These are issued one day before the week in which the work is actually to be done.

(*c*) Drawings, layouts, batch labels, material requisitions, covering all aspects of the job which the operation job cards are issued for, the first three accompanying the job throughout its whole course from start to entry into store.

However, production control does not end when planning is complete. It is necessary to monitor the happenings on the shop floor and to report them back to the production management, so that comparisons can be made between actual and planned progress. This feedback function is called " progress control."

Progress Control

The operation job card is the key to the system of progress control at Letchworth. Four copies of this document, an interpreted punched card, are prepared in the computer room, so that comparisons can be made. Of these copies, (*a*) is retained in the computer room, (*b*) is retained in the central control room, (*c*) is issued to the timekeeper, (*d*) is the shop copy, issued to the foreman with necessary documents, batch label, etc., and constituting his authority to do the work.

Although the following description of the system is related to a batch of piece parts, it also applies to assemblies as well. When the first member of a batch has been machined it is submitted for inspection. If he passes it, the inspector initials shop card (*d*) as authority to

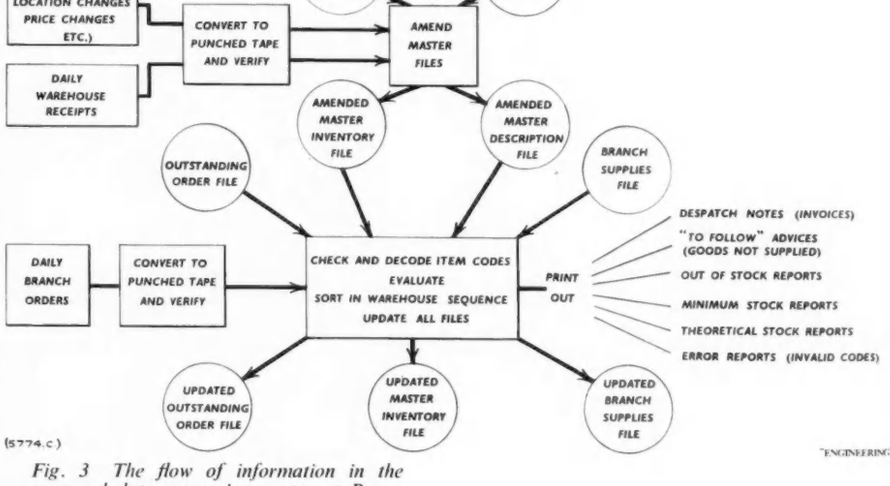


Fig. 3 The flow of information in the proposed data processing centre at Boots.

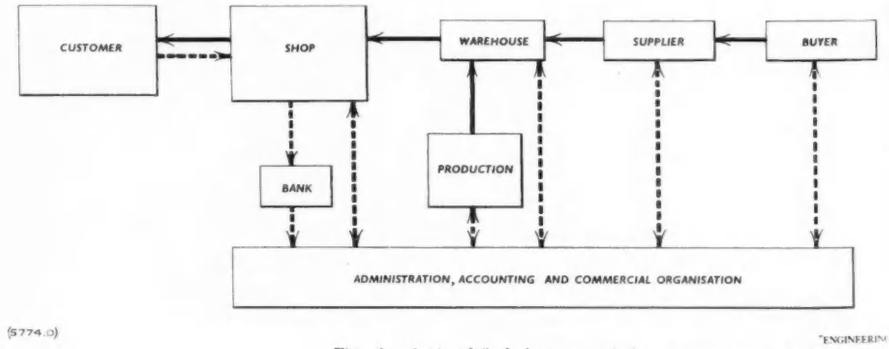


Fig. 4 A simplified diagram of the organisation of Boots Pure Drug Company Limited. Dotted lines indicate flow of data.

proceed with the making of the batch. When the batch is completed it is inspected and counted and the quantities made and passed are entered by the inspector on the shop card (*d*). The job, with batch label, layout and drawings, is then available for the next operation and a repetition of the recording procedure follows.

The shop card (*d*), which relates to only one operation, is returned to central control room, where the quantity passed good is noted and marked (for mark sensing) on control room copy (*b*). The shop card is then passed to the timekeeper who marks quantity good on his own copy (*c*) and sends this to accounts for costing and other purposes. Shop copy (*d*) he files and retains for a month in case queries arise as to bonuses. It can then be destroyed. This does not apply to the shop card (*d*) that is concerned with the final operation on the part: this books the part into store.

The marked control room copy (*b*) is passed to the computer room where the marking is sensed and punched into the card. The computer room then holds (1) its own copy (*a*) of all operations job cards issued to the shops, (2) control room copy (*b*) of all operation job cards returned from the shops relating to the jobs completed at each stage of operation, with quantity passed. A simple collation of (*a*) against (*b*) with the throwing out of unpaired cards shows which jobs are behind programme. These are then listed, section by section in priority order, each section being supplied with a precise statement of jobs in that section that are behind programme. The section head is responsible for programming these jobs to ensure their speedy completion, or for reporting back to control room why this cannot be done, for example, owing to overload or breakdown.

If conditions in any section become so serious that the work of other sections is likely to be held up, then re-loading may be necessary. By manual or by conventional mechanised methods this might well be a major operation: with the computer it presents little difficulty. Since the shops are only concerned with current and the following week's work, re-loading is largely a matter of internal re-assessment in the control room and computer room. The shops need never become aware of it.

Fig. 5 The 421/604 group performs many of the functions of a large computer. It is to be used by Kardomah Limited for stock control.

Stock Control

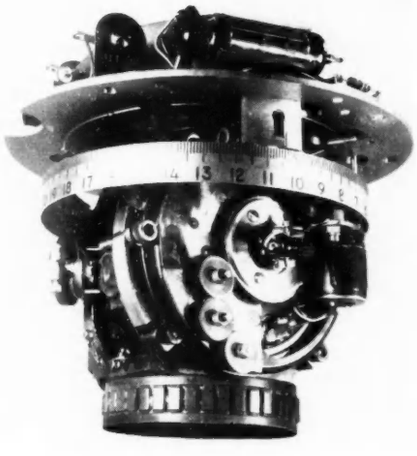
The system of stock control being developed at Letchworth provides for a weekly and a daily review. The weekly review is of the position of stocks of raw materials, of all other bought out items, and of all long-term subcontracts. The review covers, by period, ten periods representing all requirements for some 21 months ahead. A daily review is made of the position of stocks of made-in items, covering by period ten weekly periods. A normal stock control procedure is followed.

Design

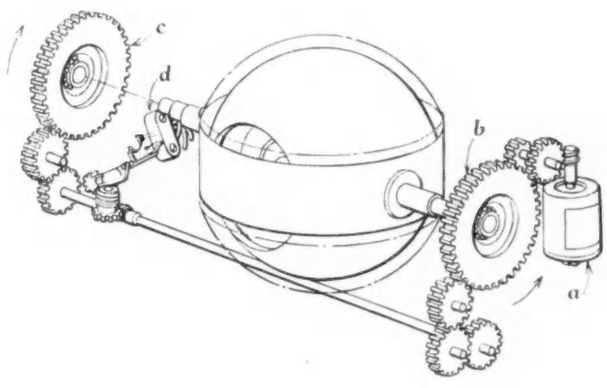
BEARINGS *for* LOW-DRIFT GYROS

One method of tackling the problem of cutting down the inherent random drift of gyroscopes for precision navigation and guidance systems is the Rotorace bearing technique, developed in the United States by the Sperry Gyroscope Company, N.Y., and now to be produced in the United Kingdom by their British associate, Sperry Gyroscope Company Limited, Brentford, Middlesex. Rotorace bearings, it may be recalled, are fitted in the non-floated C-11 Gyrosyn compasses with which USS Nautilus is equipped, and which are also being fitted to the new American jet airliners for transpolar and transoceanic navigation. The gyro unit shown on the right equipped with Rotorace bearings is part of the C-11 Gyrosyn compass for the DC8 airliner. In these instruments, the random drift is 0·5° per hour or less. In some military applications of Rotorace, random drift is held to 0·25° per hour, and in the laboratory rates as low as 0·05° per hour have been achieved under controlled conditions. (In the conventional navigational gyro, the random drift error is usually of the order of at least 3° per hour.)

Briefly, the principle of Rotorace is shown in the accompanying diagram. The aim is to eliminate error-producing torques in the gyro gimbals, and the method is to counter-rotate either the inner or the outer races of the two gimbal bearings themselves. A miniature electric motor, *a*, drives the two Rotorace bearings, *b* and *c*, in opposite directions. At fixed intervals, a reversing mechanism, *d*, reverses the directions of rotation. This combination of motions, it is claimed, gives both an averaging action and an optimum " dither " for the reduction of random drift; and, too, the bearings are rendered less sensitive to vibrating environments and therefore more constant in operation.



This gyro unit equipped with Rotorace bearings is part of the C-11 Gyrosyn compass as will be fitted in DC8 airliners.



Principle of Rotorace bearing technique: the races themselves are driven in contra-rotation, and the direction of rotation is periodically reversed.

Continuing **Design**

CONVEYOR BELTING: ENDURANCE LIVES OF TERYLENE AND COTTON COMPARED

As part of the general industrial development of high-tenacity Terylene filament yarns, a trial Terylene conveyor belt was installed at a works of ICI Lime Division, to replace a cotton belt which failed completely in just over one year. The conditions under which this conveyor operates are particularly severe; it is used for the conveyance of limestone rock direct from jaw crushers under wet conditions.

The Terylene belt was 30 in wide made from five plies of 32 oz duck with $\frac{3}{16}$ in top and $\frac{1}{16}$ in bottom rubber covers and was similar to the cotton belt previously used, except that the latter had a $\frac{5}{16}$ in thick top rubber cover. After running for $2\frac{1}{2}$ years, a point was reached when the top rubber cover could no longer be repaired satisfactorily or economically. It was apparent that further running would have resulted in damage to the carcass of the belt, and it was estimated that if it were run to destruction, as would have been the case normally, a further six months' service at least would have been obtained.

However, since the plies were virtually undamaged, it was decided in consultation with the manufacturers, the Leyland and Birmingham Rubber Company Limited, that there was a good chance of obtaining a further extended period of service from the belt if it were re-covered, as appeared possible. Accordingly, the belt was withdrawn from service and has now been re-covered, apparently satisfactorily, although since the belt which replaced it—also of Terylene—is still running, there has been no opportunity of testing the re-covered belt.

The successful performance of the Terylene belt has in part been due to the very high order of adhesion (of the order of 35 lb per in), obtained between the top rubber cover and the carcass. Less maintenance of the Terylene belt was required and such repair work as was carried out was perfectly adequate. Satisfactory repairs to the cotton belt were generally not easy to achieve, because it was difficult to dry out the canvas properly before patching on site due to the high moisture uptake exhibited by the cotton.

This is a well-known problem with conveyor belts which are running wet, and care must certainly be taken to dry them thoroughly before being patched.

A substantial economic saving has resulted from the use of Terylene conveyor belting on this installation. Its much longer life, with consequent saving on installation charges and maintenance costs, has meant that the initially higher cost of the Terylene belt, 77 per cent more than that of the cotton belt, has been completely outweighed. After $2\frac{1}{2}$ years a saving of £472 has been effected, and had the belt been run to destruction, a total saving of £491 might well have been realised. On this particular installation the Terylene belt cost 44 per cent less per ton of limestone carried than the cotton belt.

The use of 100 per cent Terylene reinforced belting on this site resulted in a saving of 44 per cent in the cost per ton of limestone carried.

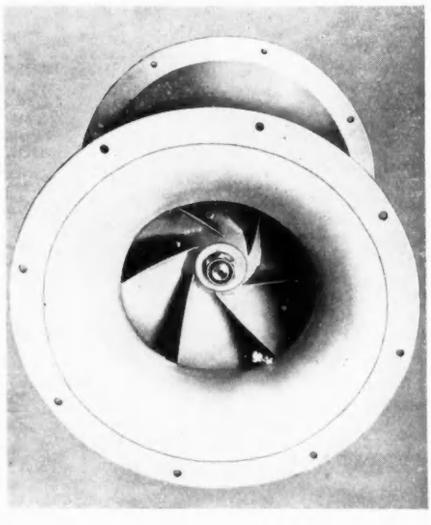
Since this experiment was carried out, much more experience has been gained on the use of newer types of Terylene yarn in the design of cheaper and better belting ducks. This has enabled manufacturers to produce 100 per cent Terylene belting which in use is even more economically attractive. In addition, it is now possible to produce certain types of Terylene reinforced belts which are cheaper than the equivalent-strength cotton belts, and it is hoped that these will be suitable for the whole field of general-purpose conveying. Field trials with these new belts are now being carried out.

COMPOUND FLOW FAN

A compound flow fan, known as the Ax-Cent, has been developed by Keith Blackman Limited, Mill Mead Road, London, N.17. It is said to combine the advantages of axial and centrifugal types, being similar in external appearance to an axial fan, yet possessing centrifugal-fan characteristics.

The cylindrical casing contains a venturi inlet to a shrouded compound-flow impeller followed by guide vanes. With a steep pressure-volume characteristic, the Ax-Cent fan contrasts sharply with the normal axial type of fan: as a single-stage unit, it provides twice the pressure development of the single-stage axial fan running at the same speed, its pressure-volume being more comparable with a two-stage axial type fan. The mechanical efficiency and relatively low sound level of the fan, Keith Blackman claim, compare very favourably with that of a centrifugal fan for equal duty.

The Ax-Cent fan can therefore be used for higher-pressure duties for which hitherto a centrifugal fan would have been necessary—but which might be difficult to accommodate because of equipment or duct layout, or because of restrictions of available space.

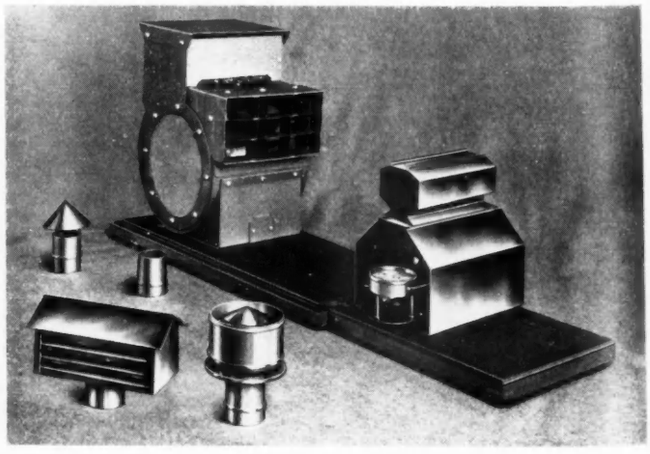


The venturi inlet to the shrouded compound-flow impeller of the Ax-Cent fan.

ASSESSING VENTILATOR DESIGN

To assist building designers in assessing—or demonstrating to clients—the behaviour of different types of ventilator, a compact ventilation testing machine for use on the office desk has been developed by Robertson Thain Limited, Ellesmere Port, Wirral, Cheshire.

When there is no wind, any hole in the roof will provide natural ventilation by reason of the temperature difference between the inside and outside of the building. The effect of wind can either oppose the efficient working of a ventilation system, or it can be effectively harnessed to augment the natural ventilation. The Robertson ventilation testing machine is, therefore, provided with a motor-driven blower to simulate wind conditions and show how they influence the behaviour of various basic designs of ventilators. It also enables the best position for fitting ventilators on any particular building to be determined.



The Robertson ventilation testing machine provides an artificial wind for assessing roof ventilators, in model form.

FAST PILOT LAUNCH

Rather more than a year ago the fast pilot launch " Leader " was launched at the Woolston, Southampton Yard of John I. Thornycroft and Company Limited. The vessel was described as an experimental craft, and the design evolved between Trinity House and Thornycroft is certainly a departure from previous Trinity House practice. She is designed to go alongside large vessels and trans-ship pilots in the open sea in all weathers.

At present, the London and Isle of Wight Pilotage Service is carried on by some eight large cutters of between 350 and 650 gross tons, each requiring a crew of 17 or more. By contrast, the " Leader " is handled by a crew of only four and also enables the pilots to remain ashore until their services are needed when they can be speedily taken to the ship to be piloted. This comparatively small craft has, therefore, the advantages of a considerably lower initial cost, economy in operation and greater comfort for the pilots.

" Leader " was put into service in July last year and since then has carried out 736 transhipments, mostly at the Needles station. During this time she has never had to be withdrawn from the Needles station because of severe weather, without the cruising cutter being withdrawn for the same reason. When the NATO fleet, which included a number of United States capital ships, visited these waters in October last, the launch established a record by effecting six shippings in 21 minutes. When attending the aircraft carrier " Forrestal," she had to pass under the flight deck which brought out the value of the telescopic mast with which she is fitted

The boat is 70 ft in overall length with a beam of 15 ft and draught of approximately 4 ft 6 in. The propelling machinery comprises two Rolls-Royce supercharged diesel marine engines, type C.8.SFLM, fitted with Thornycroft " B " type reverse gears and 2 : 1 reducing gears. Each engine develops 296 b.h.p. at 1,700 r.p.m. and with this power the ship attains a speed of 16 knots.

The fore peak is arranged as a chain locker to which there is access by a watertight hatch in the deck and an iron ladder. Adjoining is a store over which is fitted a large lift-off hatch with a ladder underneath. In the engine room, in addition to the main engines, a 1½ kW Lister auxiliary generating set is fitted, with batteries on each side. Fuel tanks, each of 250 gallons capacity, are situated on each side of the boat and a 25 gallon lubricating oil tank is fitted forward. Entrance to the engine room is by a hinged hatch and iron ladder from the inside of the wheelhouse, which is at the aft end of the engine room.

The craft has twin screws and twin rudders and the steering wheel is positioned on the centre line with the engine controls adjacent. The two radio phones (Pye f.m. v.h.f. and Marconi Seamew II medium frequency) are close to the helmsman and the Decca 212 radar viewing unit arranged to starboard. Heating of wheelhouse and the saloon is by warm air trunked from the Smith's combustion heater in the engine room. The top of the wheelhouse carries the radar scanner, searchlight, a loud hailer and a casing with lighting to display the words " Pilots " at night. Three fixed forward windows are fitted with 11 in diameter Kent " Clearview " screens. The saloon, aft of the wheelhouse, can seat 12 pilots,

The fast pilot launch " Leader " requires a crew of only four to handle her.

and is arranged so that six pilots can lie down if necessary.

The hull is constructed of double skin mahogany planking, the inner skin being ½ in and the outer ¾ in, with oiled fabric between the skins. Cathodic protection is fitted to the underwater surfaces. " Safety-Walk " non-slip tread is laid in 6 in strips on the foredeck, port and starboard.

The results achieved during " Leader's " experimental period has shown that the boat is completely satisfactory for the service required of her, and serious consideration is being given to the replacement of some of the existing cutters by further launches of this type.

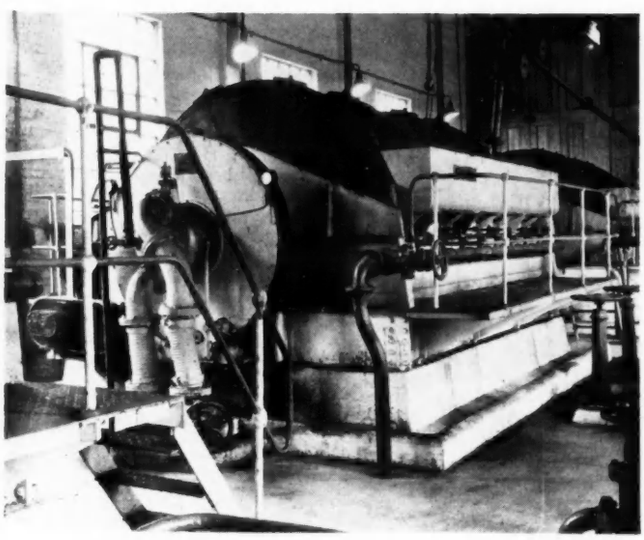
NYLON FILTERS FOR BLAST FURNACE SLUDGE

Many industries have found it necessary to install water-cleansing filter systems as a result of the stricter regulations to prevent the pollution of streams and rivers. At the Ebbw Vale works of Richard Thomas and Baldwins Limited, the iron and steel producers, the problem was not only to prevent pollution but also to conserve water, a vast quantity of which is used in cleaning gases from the blast furnaces.

The gases are cleaned by three stages. First they are passed through a dustcatcher where the heavier particles fall out. Secondly, they are passed through water towers where most of the remaining dust is removed. Finally, they are passed through electro-static precipitators, after which the clean gases are used at various departments throughout the works.

The used water, which amounts to 4,000 gallons per min, from the towers, is heavily charged with fine solid particles. It is fed to settling ponds, known as Dorr Thickeners, where the solids sink to the bottom and the relatively clean water is drawn off, cooled, and returned to the recirculation system. In the Dorr Thickeners, rake arms propel the solids to the centre of the pond where they are pumped away as sludge.

Under the original system the sludge was simply discharged into a nearby river. The new pollution regulations will make this illegal, and so an alternative method of disposal had to be found, and as an interim



Disc filters clothed with nylon have solved the problem of cleaning water heavily charged with dust particles from blast furnaces.

measure lagoons were used. At about this time expansion at the works meant increased demands for water, but as these could not be met easily by drawing more heavily on local supplies, it was necessary to devise a means of using existing quantities more efficiently.

The obvious answer was filtration, and a plant consisting of three disc filters was installed in September, 1955. This was the first of its kind in Britain and many difficulties were encountered before it operated efficiently. Not least of these was the problem of finding a suitable filtering medium. Various media were tried and eventually it was decided to use nylon, not only because of its filtering efficiency but also because it was more economical.

To-day the plant is the only one of its kind in Britain which is in full working order. By using only four discs on a single filter it is possible to remove upwards of 2 tons of cake per hour with a moisture content of about 30 per cent and on occasions the removal rate has reached as high as 4 tons per hour. Although the material is highly abrasive—consisting of more than 50 per cent iron oxide—the nylon cloths have a life of between three and four months. The fabric used is a 12 oz. per sq. yd continuous filament twill.

Continuing **Design**

FLEXURAL BEHAVIOUR *of* MILD STEEL BEAMS

By K. Farnell
B.SC. (ENG.), A.M.I.MECH.E.
Principal of Falmouth Technical Institute

The first article[1] in this series described a theory of piecemeal yielding for overstrained tension and compression members. In the second article,[2] the theory was applied to the longitudinal fibres within an overstrained beam in order to examine the stresses: firstly during loading up, and, secondly, during spring back and load reversal. Increases in load capacity due to initial tensile overstrain are discussed below.

An examination of the direct loading characteristics for steel specimens previously subjected to tensile overstrain shows that the elevation of the elastic limit in tension is accompanied by a reduction of the elastic range in compression. So far as flexural behaviour is concerned, it is evident that, with design procedures based solely on elastic failure, the use of structural members previously overstrained in tension is unlikely to lead to any increase in load capacity, as the reduced elastic range of the extreme compression fibres limits the elastic behaviour of the beam as a whole.

The limitations imposed through considerations of elasticity may be discarded when the method of plastic design is employed, as the procedure, in this case, is based upon the formation of plastic hinges within the various members. This assumption of severe local deformations for the purpose of calculating the plastic resistance of the beam section is inherent to the method and has become widely accepted. It may be of interest, therefore, to investigate the moment of resistance realised in a beam which has been pre-strained in tension before being subjected to flexural deformations of the same magnitude as those necessary for the formation of a plastic hinge in the original material. This article describes the results obtained in tests carried out for that purpose.

The test pieces were all taken from a single length of 1¼ in diameter black mild steel bar, which, in the first instance, was sawn into six lengths and then normalised as a single batch. Five of these lengths were machined up as long tensile test bars and overstrained in a tensile testing machine, each by a different amount; the final strain values before unloading ranging from 1·5 per cent to 7·5 per cent in increments of 1·5 per cent. After a period of rest, the five bars and the original unstrained bar were each used for the preparation of three further specimens suitable for one test each—tension, compression and flexure.

The tension and compression characteristics obtained in these tests are given in Figs. 1 and 2. In both graphs, the percentages refer to the maximum tensile strains attained in the original bars before unloading and re-machining. The progressive elevation of the tension characteristic according to the degree of the initial straining is clearly demonstrated and confirms what is already well known. On the other hand, the compression curves show that, although the elastic range is in all cases inferior to that of the original material, the earlier onset of strain-hardening brings about an improvement in resistance at compressive strains of the same magnitude as those likely to be attained during flexural collapse. Accordingly, it appears reasonable to suppose that a preliminary stretching operation might be used to improve the ultimate flexural resistance of a structural member.

The curves of Figs. 1 and 2 were used to forecast the flexural characteristics for six beams of rectangular section subjected to circular bending, and the resulting curves, together with the corresponding experimental values are given in Fig. 3. It will be seen that the anticipated modifications in behaviour are closely realised in practice, and it is of interest to note that the five curves for the pre-strained beams show no tendency to flatten off within the range of deformations considered. This absence of a limiting plastic moment of the type developed on the original beam introduces theoretical complications with regard to the application of present methods of plastic design, but the reserve of strength made available by the rising nature of the characteristic is attractive from a practical point of view.

Although considerable forces would be involved in the manufacture of beams of the type under consideration, the elongations to be accommodated would be only moderate, and it would not be difficult to devise a hydraulic straining machine capable of the required performance, if the process was found to offer a worth-while advantage.

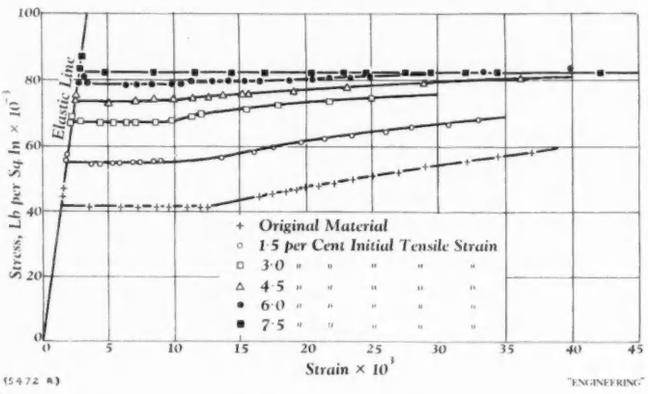

Elastic Line
Stress, Lb per Sq In × 10⁻³
Strain × 10³
+ Original Material
○ 1·5 per Cent Initial Tensile Strain
□ 3·0 " " " " "
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Fig. 1 Comparison of tensile characteristics.

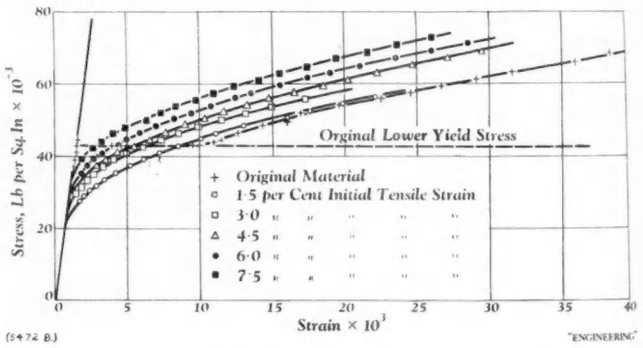
Orginal Lower Yield Stress
Stress, Lb per Sq In × 10⁻³
Strain × 10³
+ Original Material
○ 1·5 per Cent Initial Tensile Strain
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Fig. 2 Comparison of compression characteristics.

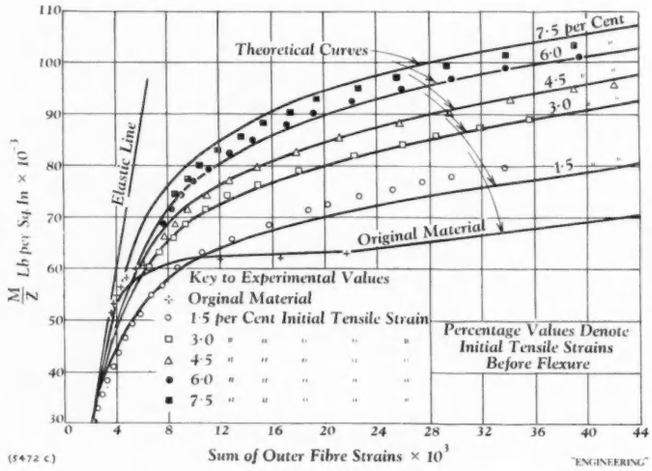

Fig. 3 Comparison of theoretical and experimental results for six beams subjected to various amounts of initial tensile overstrain before flexure.

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[1] K. Farnell, "Piecemeal Yielding of Mild Steel," ENGINEERING, p. 92, vol. 185 (1958).

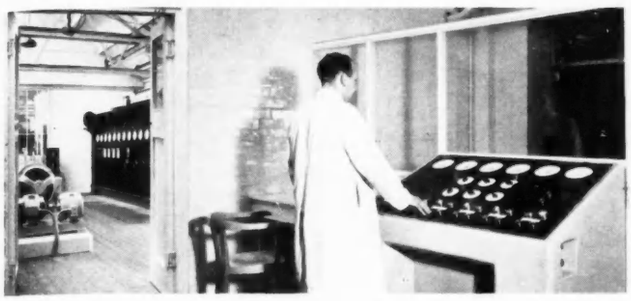
[2] K. Farnell, Stress Distribution in Overstrained Mild Steel Beams. ENGINEERING, p. 788, vol. 185 (1958).

Photocopies of the complete paper, of which the above article is a digest, are obtainable from the Publisher, ENGINEERING, *36 Bedford Street, London, W.C.2. Price 20s. each post free. Orders should be accompanied by the appropriate remittance.*

Production

QUALITY CONTROL AND DEVELOPMENT *of* WIRING ACCESSORIES

J. A. Crabtree and Company Limited, Lincoln Works, Walsall, Staffordshire, pioneered several processes and techniques in the manufacture of small electrical switchgear and wiring accessories, and from their foundation in 1919 have conducted research into the problems of design and production of their own particular products. Today the Company's laboratories are concerned with production in three ways; in providing information for the design of new products, in improving design and performance of existing lines, and in the definition and maintenance of the standards to which the products are manufactured.



Particularly intended for testing small circuit breakers and contactors, the Crabtree electrical test station can provide currents up to 10,000 A, 440 V.

A special feature of the layout is that apparatus under test can be observed at close quarters and in quiet conditions.

Metallurgical and chemical control are exercised over all raw materials; and equipment, much of it designed and built in the laboratories, is installed for both electrical and mechanical testing of prototype and production models. A range of alternating and direct current supplies is available, together with facilities for electrical testing at elevated temperatures and humidities. Tests can be carried out to meet not only British but also American, Commonwealth and European specifications.

A standard procedure is adopted in the development of a new product, which is first made by hand and after examination by all concerned from an aesthetic or practical point of view is then passed to the laboratories for mechanical and electrical testing. After any modifications suggested by the results of the tests have been made, the product is tooled, and a trial run is made, with the laboratories checking the quality standards they have laid down. At this stage the packaging is also tested.

Finally, normal production commences, and quality is then controlled by special testing stations built into each flow line. This ensures that sub-assemblies are checked for correct functioning before they pass to the final assembly point, and that the completely assembled product is tested similarly on a 100 per cent basis. In addition to this routine checking on the assembly lines, the laboratories take from the warehouse a percentage of finished and packed products and apply exhaustive tests to them, right to the point of destruction where necessary, to ensure that the required quality standard is maintained.

Changes in products bring about the need for different testing facilities, and new equipment has just been installed in the laboratories for short-circuit testing. It has become common practice in America and some European countries to use circuit breakers instead of fuses in non-industrial applications such as office blocks, shops, public institutions and even in domestic premises, and this trend is now steadily developing in this country.

Several types of miniature circuit breaker are produced at Lincoln Works, and for testing these breakers, as well as other equipment, such as contactors, a new short-circuit testing station has been built. It is designed for currents of up to 10,000 A at 440 V, 3 phase.

The generating equipment consists of an 800 kVA, 440 V, 3 phase, 4 wire alternator, with a rotating salient pole field and a designed reactance capable of giving the short-circuit current mentioned above. It is driven by a 100 h.p. squirrel cage motor with a synchronous speed of 1,500 r.p.m., and controlled by an auto-transformer starter with a Korndorffer circuit. A common bedplate carries the two machines, together with a direct-coupled exciter.

Current is fed direct from the alternator terminals to a main circuit breaker which has a normal continuous rating of 1,000 A, and a breaking capacity well in excess of the maximum short-circuit current of the alternator. A network of underfloor busbars leading from the alternator terminates in the testing cell, and reactors and resistors are connected in each phase, so that the current and power factor can be controlled down to 100 A. A "make" switch, with electronically operated point-on-wave control, is situated in the test cell.

Remote control of the complete station is effected from a control desk directly in front of the test cell, and the operator has a clear view, through a glass safety screen, of the whole progress of a test. Automatic safety devices and signals safeguard operators from risks when the plant is in operation. Because it is intended for tests on apparatus designed for manual operation by unskilled workers, the whole layout of the station is designed to enable the operators to observe the tests at close quarters and in quiet conditions, and in this respect the Crabtree test station differs from the larger short-circuit testing layouts used in the heavier branches of electrical engineering.

Upwards of 30 observers can be accommodated in the test bay, and there is a conference table for examination of apparatus before and after test. A small dark room is provided between the machine house and the test cell, so that oscillograms can be processed without delay. Forced ventilation is provided by blowing in filtered air, the building being slightly pressurised.

Provision has been made in the design of the test station for d.c. working, a battery giving 5,000 A at 250 V and over 2,000 A at 500 V. Higher test voltages are also catered for by provision in the busbar system for the connection of transformers as required.

GAS BY GRID

Integrated System for S.W. England

A 295 mile long gas grid now connects twelve modern gas works lying between Evesham in Worcestershire and Penzance in Cornwall. The final linking-up ceremony was carried out on 16 October by Sir Harold Smith, chairman of the Gas Council, at Harberton, near Totnes, in Devon, when an inscribed length of spun-iron pipe was lowered into place. The grid allows complete interchange of gas between the works dependant on where the peak demand occurs within this area supplied by the South-Western Gas Board.

One of the main aims of research and development work being carried out by several of the Regional Gas Boards is to produce a gas which is non-toxic and free from sulphur, hydrogenation of coal, oil and petroleum distillates being the method which is probably receiving the most attention.

Mr. H. C. Chester, who is chairman of the South-Western Gas Board, said during the ceremony at Harberton, that distribution of such gas would commence within two years to Bristol and Bath districts, but further extension would follow to Swindon, Weston-Super-Mare, Exeter, Torquay and Plymouth districts. There were advantages to both the domestic and industrial consumer. Sulphur-free gas would mean a considerable extension of the use of flueless appliances and would be of great assistance in further development of material and metal-processing.

Metals and Materials

NEW SHEET AND WIRE GAUGES?

The International Organisation for Standardisation is proposing adoption of a new series of gauge thicknesses for sheet and wire which is based on the system of "Preferred numbers." The series is metric. In America, where the most widely used unit of length is the inch, there has been a tentative proposal put forward by the American Standards Institute to introduce a similar inch series, but this has not yet reached the committee stage in ISO. British industry has been invited by the British Standards Institution to voice its opinion in this matter, especially as to whether such new series are necessary and would be well received in this country.

Buyers and sellers of sheet and wire in the United Kingdom have been blessed with at least eight series of thickness gauges. Applied individually each could serve a useful purpose, but considered together they destroy their usefulness and form a first stepping stone to delay and expense. It is not surprising that the initial reaction of industry in Britain has been to admit "We are confused over the existing series" with an appropriate word of protest. Remembering overseas markets, no one series either metric or inch, could satisfy all British industry. However, the basis of Preferred numbers is very sound, and if all the existing series were sacrificed for one metric and one inch series the air would become much clearer. There will always be a place for commodities produced to a specified size and tolerance, but these will continue to be special products made at a premium, which present quite different problems from those encountered in the supply of material to standard sizes.

Col. Charles Renard was the French engineer who first proposed the use of Preferred numbers; hence arises the common reference to them as "Renard" numbers and the "R" in R5, R10, R20, R40, and R80 by which the series are known. Preferred numbers are arbitrarily rounded-off values derived from geometric series having one of the common ratios $\sqrt{10}$, $\sqrt[10]{10}$, $\sqrt[5]{10}$, $\sqrt[40]{10}$, and $\sqrt[80]{10}$ which are approximately equal to 1·58, 1·26, 1·12, 1·06 and 1·03 respectively. The numbers do not, however, define the basic unit. That the metric and inch series based on Preferred numbers would never exactly correspond, results primarily from the fact that 1 in equals 25·4 mm and not 25·0 mm. The sixteenth number in the R40 series is 2·50, and gauge 16 based on the unit of 10 mm is therefore about 2 per cent different from gauge 1 based on a unit of 1 in. This discrepancy is small but destroys any hope of a perfect inch/metric series using simple figures. Comparison of the Preferred number series with s.w.g. and b.g., as is partly shown in the table below, indicates that the ISO metric series include the s.w.g. and b.g. sizes with only small differences.

If and when BSI, ASA and ISO are able to agree on the introduction of one or two series, the question will arise as to whether they will be adopted by industry. If they are not, Britain may soon be the only country using her present series, which could easily damage her export trade as well as leave her own house in its present state of confusion.

Further information on Preferred numbers is available in B.S. 1638: 1950 and B.S. 2045: 1953 and discussion of the proposed series in *B.S.I. News* commencing July, 1958.

ISO Series in mm			Equivalent size in inches	Proposed US series in inches	S.W.G.		B.G.	
R.10	R.20	R.40			Number	Size in inches	Number	Size in inches
0·500	0·500	0·500	0·01969	0·020	25	0·020	26	0·01961
—	—	0·530	0·02087	—	—	—	—	—
—	0·560	0·560	0·02205	0·022	24	0·022	25	0·02204
—	—	0·600	0·02362	0·024	23	0·024	—	—
0·630	0·630	0·630	0·02480	0·025	—	—	24	0·02476
—	—	0·670	0·02638	0·026	—	—	—	—
—	0·710	0·710	0·02795	0·028	22	0·028	23	0·02782
—	—	0·750	0·02953	0·030	—	—	—	—
0·800	0·800	0·800	0·03150	0·032	21	0·032	22	0·03125
—	—	0·850	0·03346	0·034	—	—	—	—
—	0·900	0·900	0·03543	0·036	20	0·036	21	0·0349
—	—	0·950	0·03740	0·038	—	—	—	—
1·000	1·000	1·000	0·0394	0·040	19	0·040	20	0·0392
—	—	1·06	0·0417	0·042	—	—	—	—
—	1·12	1·12	0·0441	0·045	18	0·048	19	0·044
—	—	1·18	0·0465	0·048	—	—	—	—
1·25	1·25	1·25	0·0492	0·050	—	—	18	0·0495
—	—	1·32	0·0520	0·053	—	—	—	—
—	1·40	1·40	0·0552	0·056	17	0·056	17	0·0556
—	—	1·50	0·0591	0·060	—	—	—	—
1·60	1·60	1·60	0·0630	0·063	16	0·064	16	0·0625
—	—	1·70	0·0669	0·067	—	—	—	—
—	1·80	1·80	0·0709	0·071	15	0·072	15	0·0699
—	—	1·90	0·0748	0·075	—	—	—	—
2·00	2·00	2·00	0·0787	0·080	14	0·080	14	0·0785

MIST-REDUCING ADDITIVES *for* CHROMIUM PLATING BATHS

Chromic acid mist is one of the oldest members of the family of smogs and condensates which are detrimental to the health of those who are unfortunate enough to inhale them. Luckily, one would only be likely to encounter this particular mist in the chromium plating business, where, however, HM Inspectors of Factories make sure that fume extractors are fitted with sufficient capacity to reduce the acid concentration to below the safe limit of 0·1 milligram per cubic metre of air. The spray which is normally to be found above a chromium plating bath is caused by the bursting of bubbles of oxygen and hydrogen which are produced at anode and cathode during plating.

Several additives have been suggested to prevent formation of the spray, most of them acting by reducing surface tension of the electrolyte to such an extent that a layer of foam is produced which prevents the breaking of bubbles from throwing acid particles into the air. Use of floating plastics beads and rods which would act in a similar manner has also been suggested.

Many of the proposed surface-active agents are organic sulphonic acids, but these unfortunately break down very quickly in the oxidising atmosphere of the chromic acid. There is, however, one compound—a fluorinated hydrocarbon—which is not only effective, but is also stable. Named Zero-mist, it is made by the Unilite Corporation of Detroit 11, Michigan, USA and is marketed in this country by the Electro-Chemical Engineering Company Limited, of Sheerwater, Woking, Surrey. This additive to chromium plating baths has proved so successful in reducing mist that the Factory Act has been amended to allow plating baths which incorporate the material to be used without any air-extraction system. Those who have had to sign the cheques for capital investment in plating baths or who have experienced the health hazard in chromic acid will realise that this material is causing a revolution in the chromium plating world. Substantial savings in chromic acid which otherwise would go up the flue as mist have already been recorded. In Birmingham, the installation of a plant incorporating the material has allowed a saving of £590 which would otherwise have been spent on a more efficient air extraction system. Total cost of the Zero-mist was £110 when added at the rate of 3 lb per 100 gallons to the two 300 gallon baths. Reduced dragout of chromic acid because of the lower surface tension allowed a further saving and figures of up to 70 per cent reduction in loss of acid have been recorded in such installations.

One of the nightmares of the plater is staining; he is only able to overcome the difficulty by more efficient washing after plating, but in most cases this involves being served with a larger water bill. Lowered surface tension, in reducing dragout and facilitating washing, is therefore, to say the least, helpful. Technically-minded insurance agents who think that such additions which create a foam containing an explosive mixture of oxygen and hydrogen offer a reason for increasing their premiums, are doomed to disappointment; there is no such danger.

Zero-mist is soon to have a brother. Conceived in America by Unilite, the new material is intended for addition to chromium plating baths operated at temperatures higher than those currently in use, at which Zero-mist, to be effective, would have to be added in quantities too large to prove economical.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

CROYDON
"Developments in Floor Heating," by K. G. Stephenson. South London Branch. Greyhound Hotel, High Street, Croydon. Thurs., 27 Nov., 8 p.m.
HANLEY
"Power Factor Correction," by F. T. Bartho. Stoke and Crewe Branch. Grand Hotel, Hanley. Fri., 28 Nov., 7.30 p.m.

British Institution of Radio Engineers

LONDON
Annual General Meeting at 6 p.m.* Presidential Address by Professor E. E. Zepler at 7.15 p.m. London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1. Wed., 26 Nov.
BRISTOL
"Electronic Transducers," by G. F. N. Knewstub. South Western Section. School of Management Studies, Unity Street, Bristol 1. Tues., 25 Nov., 7 p.m.
CHELTENHAM
"Television Recording," by P. J. Guy. South Midlands Section. North Gloucestershire Technical College, Cheltenham. Fri., 28 Nov., 7 p.m.

Building Centre

LONDON
Films on the manufacture of venetian blind slats, exhibited by Hunter Douglas (Gt. Britain) Ltd. Wed., 26 Nov., 12.45 p.m.

Chemical Society

BANGOR
"Reaction Mechanisms," by Professor E. D. Hughes. North Wales Branch. Department of Chemistry, University College of North Wales, Bangor. Thurs., 27 Nov., 5.45 p.m.
BRISTOL
"Crystalline High Polymers," by Professor C. E. H. Bawn. Bristol Branch. Chemistry Department, The University, Bristol. Thurs., 27 Nov., 5.15 p.m.
EXETER
"Porous Crystals as Sorbents and Molecular Sieves," by Professor R. M. Barrer. Exeter Branch. Washington Singer Laboratories, Prince of Wales Road, Exeter. Fri., 28 Nov., 5 p.m.

Combustion Engineering Association

BIRMINGHAM
"Shell Type Boilers: Lancashire and Various Types of Economic Boilers: Their Ratings, Efficiencies and Heat Flow," by H. E. Pearsall. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2. Wed., 26 Nov., 10 a.m.

Illuminating Engineering Society

BIRMINGHAM
"Headlamps and Signals for Motor Cars," by J. H. Nelson. Birmingham Centre. Regent House, St. Phillip's Place, Colmore Row, Birmingham. Fri., 28 Nov., 6 p.m.
LEEDS
"Australian Journey," by W. E. Harper. Leeds Centre. Offices of the British Lighting Council, 24 Aire Street, Leeds 1. Mon., 24 Nov., 6.15 p.m.
LEICESTER
"Work of the Building Research Station," by P. Petherbridge. Leicester Centre. Offices of the East Midlands Electricity Board, Charles Street, Leicester. Mon., 24 Nov., 7 p.m.

Incorporated Plant Engineers

BIRMINGHAM
Discussion on "Statutory Regulations for Steam and Pressure Vessels" (with films). Birmingham Branch. Imperial Hotel, Temple Street, Birmingham. Fri., 28 Nov., 7.30 p.m.
CARDIFF
"Corrosion," by D. W. Marshall. South Wales Branch. South Wales Institute of Engineers, Park Place, Cardiff. Tues., 25 Nov., 7.30 p.m.
LEEDS
"Rocket Propulsion and Control," by D. Hurden. West and East Yorkshire Branch. Fuel Department, New Building, The University, Leeds. Mon., 24 Nov., 7.30 p.m.
LIVERPOOL
"Some Aspects of Automatic Control," by R. E. Harvison. Merseyside and North Wales Branch. Exchange Hotel, Liverpool. Thurs., 27 Nov., 7.15 p.m.

Incorporated Sales Managers' Association

WOLVERHAMPTON
Open Discussion Meeting, being held jointly with the Purchasing Officers' Association. South Staffordshire Branch. Victoria Hotel, Wolverhampton. Tues., 25 Nov., 7.30 p.m.

Institute of Marine Engineers

LONDON
Sir Charles Parsons Memorial Lecture on "Recent Advances in Nuclear Engineering," by Sir John Cockcroft. Wed., 26 Nov., 5.30 p.m.*
CARDIFF
"Gas Turbines," by D. L. Brown. South Wales Section. Welsh College of Advanced Technology, Cathays Park, Cardiff. Mon., 24 Nov., 7 p.m.
LIVERPOOL
"Marine Diesel Engines," by D. B. Stables. Merseyside and North Western Section. Riversdale Technical College, Liverpool. Wed., 26 Nov., 5.30 p.m.

Institution of Chemical Engineers

LONDON
"An Extended Equation for the Performance of Machines Mixing Two Powders," by H. E. Rose. Geological Society, Burlington House, Piccadilly, W.1. Tues., 25 Nov., 5.30 p.m.*
BIRKENHEAD
"Pollution Law and the Chemical Engineer," by R. R. Ferner. North Western Branch. Birkenhead Technical College, Birkenhead. Tues., 25 Nov., 7 p.m.

Institution of Civil Engineers

LONDON
"A Study of Traffic Flow, Its Seasonal Variation, and Relation to Traffic Capacity Standards, with Special Reference to Parts of Dorset," by J. I. Whitehead. Tues., 25 Nov., 5.30 p.m.*
CHESTER
"Layout of Roundabouts in Rural Areas," by A. G. Tyson. North Western Association. Queen Hotel, Chester. Thurs., 27 Nov., 7.30 p.m.

Institution of Electrical Engineers

LONDON
"Use of Dispersive Dielectrics in a Beam-Scanning Prism," by Dr. J. S. Seeley and Dr. J. Brown; "The Quarter-Wave Matching of Dispersive Materials," by Dr. J. S. Seeley; and "Theory of Reflections from the Rodded-Type Artificial Dielectric," by A. Carne and Dr. J. Brown. Radio and Telecommunication Section. Mon., 24 Nov., 5.30 p.m.*
"Investigations of Power-Follow Current Phenomena Using a Synthetic Power Source," by Dr. L. L. Alston and Professor F. M. Bruce; and "The Impulse Initiation of Arc Discharges," by Dr. L. L. Alston. Supply Section. Wed., 26 Nov., 5.30 p.m.*
Symposium of papers on "The Provision of Adequate Electrical Installations in Buildings." Utilization Section. Thurs., 27 Nov., 2.30 p.m. and 5.30 p.m.*
BIRMINGHAM
Discussion on "Modern Industrial Applications of Field Plotting," opened by E. R. Hartill. South Midland Centre. College of Technology, Gosta Green, Birmingham. Wed., 26 Nov., 6.15 p.m.*
BRISTOL
Faraday Lecture on "Automation," by Dr. H. A. Thomas. Western Centre. Colston Hall, Bristol. Thurs., 27 Nov., 6.45 p.m.
CHESTER
"Recognition of Moving Vehicles by Electronic Means," by T. S. Pick and A. Readman. Mersey and North Wales Centre. Town Hall, Chester. Mon., 24 Nov., 6.30 p.m.
DERBY
"Importance of Research in Hearing and Seeing to the Future of Telecommunication Engineering," by Dr. E. C. Cherry. East Midland Centre. Offices of the East Midlands Electricity Board, Derby. Mon., 24 Nov., 6.30 p.m.*
FARNBOROUGH
"Operational Experience at Calder Hall," by K. L. Stretch. Southern Centre. RAE Technical College, Farnborough. Wed., 26 Nov., 6.30 p.m.*
GLASGOW
"Supply-Voltage and Current Variations Produced by a 60 ton Three-Phase Electric-Arc Furnace," by Dr. B. C. Robinson and A. I. Winder. South West Scotland Sub-centre, Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2. Wed., 26 Nov., 7 p.m.

Institution of Electronics

MANCHESTER
"Electronic Telephone Exchanges," by Dr. J. E. Flood. Northern Division. Manchester College of Science and Technology, Sackville Street, Manchester. Fri., 28 Nov., 7 p.m.

Institution of Engineering Designers

BRADFORD
"Jodrell Bank Radio Telescope," by C. N. Kington; and film on "The Inquisitive Giant." Yorkshire Branch. Midland Hotel, Bradford. Wed., 26 Nov., 7.30 p.m.

Institution of Heating and Ventilating Engineers

EDINBURGH
"Air Filtration: Why and How," by G. H. Vokes. Scottish Branch. 25 Charlotte Square, Edinburgh. Tues., 25 Nov., 7 p.m.
LIVERPOOL
"Hospital Engineering Services," by E. S. Hancock. Liverpool Branch. College of Building, Clarence Street, Liverpool. Fri., 28 Nov., 6.30 p.m.

Institution of Highway Engineers

CARLISLE
Discussion on "Mechanical Plant Used in Motorway Construction." Northern Branch. The Courts, Carlisle. Fri., 28 Nov., 7 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Accessibility in Vehicle Design." Automobile Division. Tues., 25 Nov., 6 p.m.*
"A Possible Nuclear Reactor System for the Propulsion of Ships," by A. N. Byford. London Graduates' Section. Wed., 26 Nov., 6 p.m.*
Technical Film Show: "Forming of Metals," "Magnifying Time," "Variety Reduction" and "Particles Court." Fri., 28 Nov., 6 p.m. (Tickets required.)
BRADFORD
Discussion on "Teaching of Nuclear Engineering for Power Generation," by A. D. Collop. Yorkshire Branch. Institute of Technology, Bradford. Tues., 25 Nov., 6.30 p.m.
BURNLEY
"Machine Tool Developments in the USSR," by Norman Stubbs. Blackburn Panel. Central Library, Grimshaw Street, Burnley. Wed., 26 Nov., 7 p.m.
DERBY
"Some Aspects of Reactor Design for Ship Propulsion," by J. S. Hollings. East Midlands Branch. Rolls-Royce Welfare Hall, Derby. Mon., 24 Nov., 6.15 p.m.
OXFORD
Thomas Hawksley Lecture: "Transmission of Acoustic Waves Through Structures," by Professor L. L. Beranek. Eastern Branch. Clarendon Laboratory, Oxford. Thurs., 27 Nov., 7.30 p.m.
READING
"Vacuum Techniques in the Atomic Energy Industry," by H. Kronberger. Southern Branch. Reading Technical College, Reading. Wed., 26 Nov., 7.30 p.m.

Institution of Production Engineers

CARDIFF
"Tooling with Epoxy Resins," by E. M. White. Cardiff Section. South Wales Institute of Engineers, Park Place, Cardiff. Fri., 28 Nov., 7 p.m.
LINCOLN
"Factors Affecting Cutting Tool Performance," by R. J. Cowie. Lincoln Section. Ruston Club, Lincoln. Thurs., 27 Nov., 7.30 p.m.
MANCHESTER
"Diploma in Technology," by Dr. A. Whitworth. Manchester Section. Manchester College of Science and Technology, Sackville Street, Manchester. Mon., 24 Nov., 7.15 p.m.
STOKE-ON-TRENT
"Use of Rubber in Engineering," by Dr. A. N. Gent. Stoke-on-Trent Section. Grand Hotel, Hanley, Stoke-on-Trent. Mon., 24 Nov., 7.30 p.m.

Institution of the Rubber Industry

MANCHESTER
"Air Suspensions: A Tyre Engineer's Point of View," by V. E. Gough. Manchester Section., Grand Hotel, Manchester. Mon., 24 Nov., 6.45 p.m.

Institution of Structural Engineers

LONDON
"Modern Methods of Fabricating Structural Steelwork," by M. F. Palmer and R. J. Fowler. Thurs., 27 Nov., 6 p.m.*
GLASGOW
"Application of Welding to Structural Engineering," by David Watson. Scottish Branch. 39 Elmbank Crescent, Glasgow, C.2. Tues., 25 Nov., 7 p.m.

Junior Institution of Engineers

LONDON
Annual General Meeting. Fri., 28 Nov., 7 p.m.*

Liverpool Engineering Society

LIVERPOOL
"Forgemasters in Steel," by G. W. Ellis, with film display. Wed., 26 Nov., 6 p.m.

Manchester Association of Engineers

MANCHESTER
"Electro-Mechanical Themes in Machine Tool Design," by the Earl of Halsbury. College of Science and Technology, Sackville Street, Manchester. Fri., 28 Nov., 6.45 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE UPON TYNE
"Tests on Light-Alloy Stiffener Sections," by M. N. Parker and K. V. Taylor. Neville Hall, Westgate Road, Newcastle upon Tyne. Fri., 28 Nov., 6.15 p.m.*

Physical Society

LONDON
Ninth Rutherford Lecture on "General Implications of the Discovery of the Atomic Nucleus," by Professor Niels Bohr. Chemistry Department, Imperial College, S.W.7. Fri., 28 Nov., 5 p.m.

Royal Society of Arts

LONDON
"The Birth of the Aeroplane," by C. H. Gibbs-Smith. Mon., 24 Nov., 6 p.m.

Royal Statistical Society

SHEFFIELD
"A New Approach to Control Chart Theory," by Professor G. A. Barnard. Sheffield Industrial Applications Group. Grand Hotel, Sheffield. Thurs., 27 Nov., 7 p.m.*

Sheffield Metallurgical Association

SHEFFIELD
"Development in Use of Absorptiometer and Spectrophotometer for Methods of Analysis," by A. A. R. Wood. BISRA Laboratories, Hoyle Street, Sheffield. Tues., 25 Nov., 7 p.m.

Society of Instrument Technology

LONDON
"Digital Data-Recording for Nuclear Experiments," by R. C. M. Barnes. Data Processing Section. Manson House, Portland Place, W.1. Tues., 25 Nov., 6 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than three weeks before the date of the meeting.

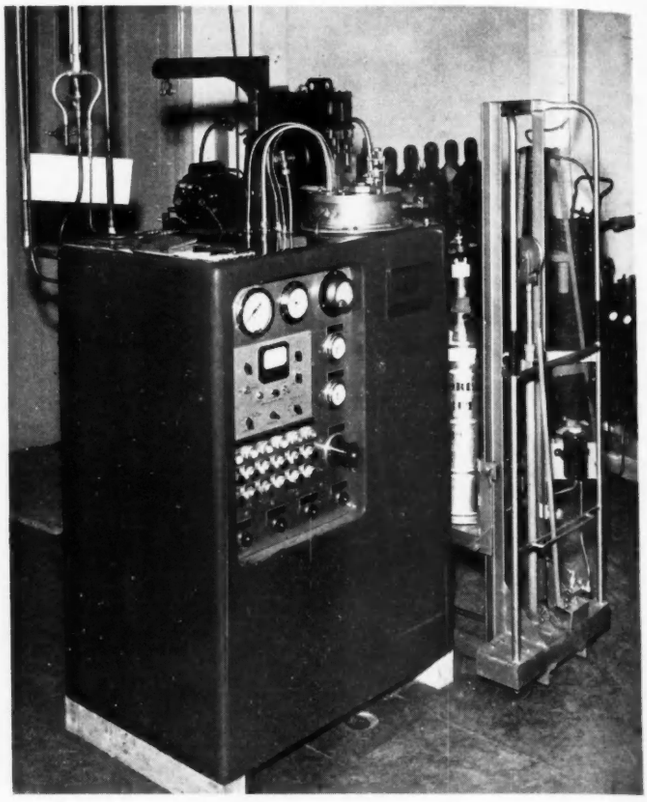
* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford Square, London, W.C.1. (MUSeum 1901.)
Building Centre, 26 Store Street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke Street, St. James's, London, S.W.1. (WHItehall 5536.)
Illuminating Engineering Society, 32 Victoria Street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 2 Grosvenor Gardens, London, S.W.1. (SLOane 0469.)
Incorporated Sales Managers' Association, 51 Palace Street, London, S.W.1. (VICtoria 1461.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, E.C.3. (ROYal 8493.)
Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George Street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Electronics, 78 Shaw Road, Thornham, Rochdale, Lancs. (Oldham Main 6661.)
Institution of Engineering Designers, 38 Portland Place, London, W.1. (LANgham 8847.)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria Street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield Street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, S.W.1. (VICtoria 0786.)
Liverpool Engineering Society, 9 The Temple, 24 Dale Street, Liverpool 2. (Central 3717.)
Manchester Association of Engineers, 18 Booth Street, Manchester 2. (Central 1717.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle upon Tyne 1. (Newcastle 20289.)
Physical Society, 1 Lowther Gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck Street, London, W.1. (WELbeck 7638.)
Sheffield Metallurgical Association, 64 Crescent Road, Sheffield 7. (Sheffield 52865.)
Society of Instrument Technology, 20 Queen Anne Stret, London, W.1. (LANgham 4251.)

Research and Development

RESEARCH NEAR ABSOLUTE ZERO

Work in Progress at a University, a Government Establishment and an Industrial Laboratory



Liquid helium, essential for low temperature work, is supplied regularly by the NPL to 14 users. Their liquefier is the commercial unit shown in the illustration, which produces up to 6 litres per hour. (Crown copyright reserved)

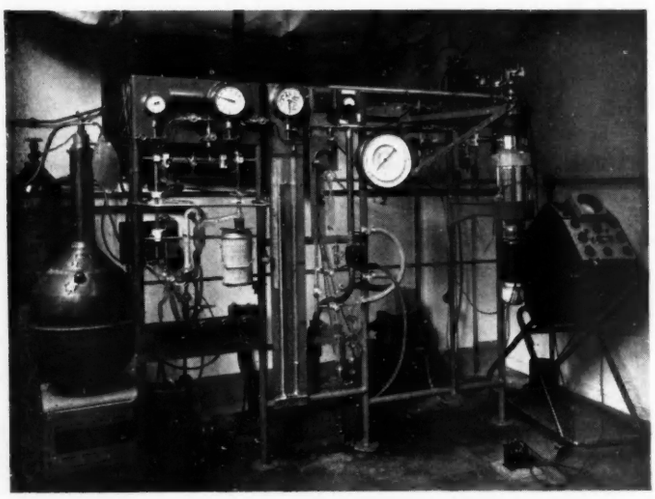
Discovered in the sun's atmosphere before isolated in the laboratory, deriving its name from the Greek name for the sun, helium finds no rivals as a medium for achieving low temperatures. An inert gas, it liquefies at 4·2° K. It was first liquified 50 years ago, but only in recent years has it become of importance to engineering.

There are several reasons for this. The development of a commercial helium liquefier in 1947 led to an increase in research at low temperatures. As a result, new devices and techniques were developed. Cryotrons—minute switches that scale down the size of a digital computer without impairing its capacity to calculate—were announced in 1956. These are superconducting devices that operate in liquid helium, the " cryo " stem having been generally adopted for this temperature range: a cryostat, for example, is a chamber capable of maintaining such temperatures. Masers—radio amplifiers that promise to be about 100 times as sensitive as conventional equipment—also operate in liquid helium.

As far as techniques are concerned, many advantages are gained by the study of materials at temperatures near absolute zero. When a material is cooled to this extent, the thermal motion of the atoms is reduced sufficiently for its interfering effect to be removed. Not only does this allow precision measurement of certain important parameters of the material, but it also enables atomic and nuclear events in solids to be studied. Whereas the physicist was previously only able to study the interaction of single atoms and particles, now, by cooling materials to low temperatures, he can observe the behaviour of large groups of atoms. A striking example of this method was the demonstration of the non-conservation of parity in the beta-decay of cobalt 60—the demonstration showing that in certain nuclear reactions Nature does distinguish between left-handedness and right-handedness, whereas previously it had been accepted that any process and its mirror image had an equal chance of occurring. For such an experiment, of fundamental importance to any comprehensive theory of matter, cooling of the block of cobalt by liquid helium (to allow alignment of the atoms) was essential.

The chief obstacle to the widespread use of liquid helium is the geographical distribution of the gas. There are no natural sources of the gas in Britain; most of the work carried out in this country has made use of helium imported from the United States, where it occurs as a by-product of oil wells. As a result, excellent fundamental research at low temperatures has been carried out here but little commercial development has occured. The UKAEA has been investigating reports of helium in Tanganyika (the gas is a potential heat transfer medium in the high temperature gas-cooled reactor) but only very small quantities have been discovered. However, the number of industrial laboratories using liquid helium is increasing and United States experiments on the extraction of helium from waste gases by diffusion through glass are being watched with interest.

A commercial helium liquefier is produced by Arthur D. Little Incorporated, 30 Memorial Drive, Cambridge, Massachusetts. It produces liquid helium at a rate between 3 and 6 litres per hour, depending on whether liquid nitrogen pre-cooling is used or not. There are two of these machines in the United Kingdom: one was installed at the National Physical Laboratory, Teddington, in 1952, under the Marshall Aid



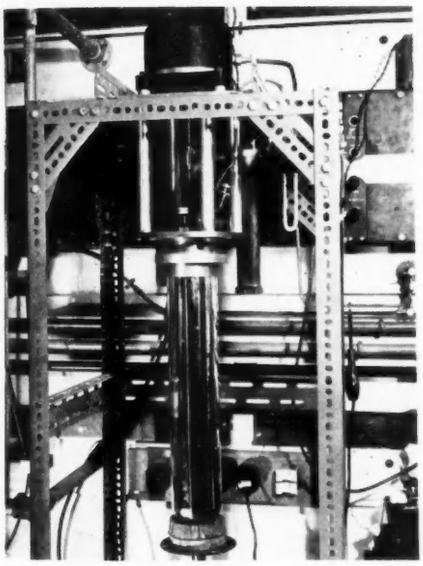
A complete liquid helium apparatus set up for a superconducting experiment: the experimental glass Dewar vessels are on the right; the storage vessel is on the left; helium gas is collected in the rubber bag at the top. Most of the pipework is for measurement and control of temperature. (By permission of the Admiralty; Crown copyright reserved)

programme, the other was installed at Bristol University in 1957. By comparison, there are about 100 units in operation in the United States. Laboratories in Britain having large liquefiers of their own construction are to be found at the Royal Radar Establishment, Malvern, Oxford University, and Cambridge University.

To encourage British research at low temperatures, the Liquid Helium Distribution Scheme was set up. By this scheme, the helium is liquefied in bulk at the NPL and sent out to laboratories that are members of the pool. In addition, those laboratories capable of producing their own liquid helium can also call on the resources of the pool if, for example, their own liquefier broke down. Double Dewar vessels capable of containing 16 litres of liquid are available for transport purposes; these travel by road or rail with very little loss by evaporation.

In the illustration of the NPL liquefier (Fig. 1) a helium Dewar is positioned on a hydraulic lift in readiness for filling. The liquefier is now producing about 80 litres per week for sale, about double the amount sold per week last year. Distribution is made regularly to 14 different users, including the Services Electronics Research Laboratory, General Electric Company Limited, Mullard Limited, Leeds University, AERE Harwell, and the Signals Research and Development Establishment. An important platform for discussion of work in this field is provided by the Low Temperature Group of the Physical Society.

As an indication of the work being carried out in this country, the programmes of three establishments using low temperature apparatus are outlined below. They are a university laboratory, a government laboratory, and an industrial laboratory.



A typical cryostat for fatigue experiments at the Clarendon. A connecting rod from the inverted Goodmans vibration generator at the top of the frame passes through a gland into the Dewar flask and applies load cycles to the specimen.

MATERIAL PROPERTIES

A broad programme of fundamental research into the properties of materials at very low temperatures is in progress at the Clarendon Laboratory of the University of Oxford. There are over 150 research workers in the laboratory and of these more than 40 work in the low temperature group; in addition there is a technical staff of 60. A helium liquefier with a capacity of 12 litres per hour and a hydrogen liquefier with a capacity of 18 litres per hour serve about 30 cryostats.

Much of the low temperature work is concerned with the properties of liquid helium and pure metals. There is an extensive study of magnetic effects, and temperatures of about 20 microdegrees K have been reached with nuclear magnetic cooling. Studies are also being made of the properties of liquid helium at pressures of 30,000 atmospheres. Liquid helium, being very compressible, is an excellent material for the study of phenomena of this pressure range, which represents the limit that can be reached with convenient laboratory techniques.

Among the projects that have a direct bearing on engineering are studies of the strength and fatigue properties of pure metals—carried out with the object of establishing a fundamental theory of the fatigue process. Copper and similar face-centre-cubic metals are studied rather than body-centre-cubic varieties, because the latter become brittle at low temperatures. In one set of fatigue experiments metallic specimens are subjected to cyclic stress at low temperatures and the changes occurring in the structure of the specimen are studied by electrical resistance and heat conduction measurements. The specimens are contained within the chamber of a cryostat and stresses are applied to them by long rods connected to Goodman vibrators. Fig. 3 shows a typical experimental set-up; the specimens examined are about 0·5 mm in diameter and 1 cm long.

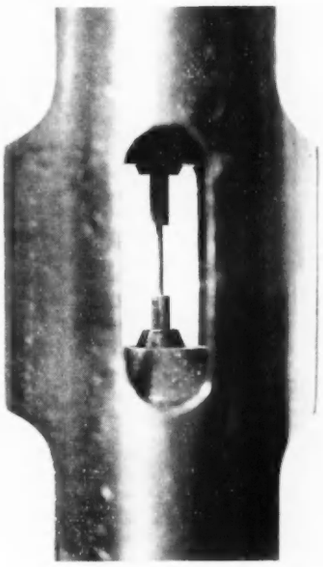
Fatigue failure appears to quite similar at liquid helium temperatures to fatigue failure at room temperature; although the material is a lot tougher, the ultimate fracture looks much the same. This limits the number of mechanisms that can be put forward to explain fatigue. At the temperature of the experiments the fatigue crack cannot be started by corrosion or inward diffusion of oxygen, because these processes are absent at the temperatures concerned. Thus an alternative mechanism must be found to explain the initiation of the crack at low temperatures, although other mechanisms may come into play at higher temperatures. The initiation of the fatigue crack at the intersection of two different slip systems has been one hypothesis advanced. This was the result of electron microscope examination of a specimen subjected to 1 per cent of the stress necessary to produce fatigue failure at 4·2° K.

Evidence has also been gained that fatigue and stretching cause two different types of work hardening. A guide to the amount of damage done to the structure of a metal as it work hardens is the increase in the electrical resistance. But as a specimen is fatigued, the resistance does not increase continuously, it reaches a limit. The value of the limit resistance in the case of fatigue hardening is about 10 times the value that would be obtained if the specimen was stretched to the same stress level. This suggests that during the fatigue process many more defects are formed than during simple stretching of the metal. It is thought that many of these extra defects may be stacking faults.

However, electrical resistance measurements by themselves tend to be difficult to interpret—many different causes can contribute to the total change in resistance. Heat conduction measurements offer, in some cases, a more refined tool for investigating damage. Heat conduction through a metal is possible by two means: conduction by electrons and conduction by lattice vibrations or phonons. In general as a metal is alloyed, the electronic conduction decreases while the phonon conduction stays approximately constant. This is true in the liquid helium range. By studying the phonon heat conductivity instead of the electron heat conductivity it is possible to gain more information about the defects caused by work hardening. This is because phonon conduction is a selective process (whereas all defects affect the electron conduction). And although the electron distribution does not change a great deal between room temperature and liquid helium temperature, the lattice wavelength changes quite a lot: at low temperatures the wavelength is long, at high temperatures it is short. Thus defects of different sizes are detected by measuring the phonon conduction at different temperatures. At high temperatures the short lattice vibrations will be scattered by point defects in the metal, at low temperatures the lattice wavelength increases and the small defects will not scatter the vibrations so effectively.

PHONON CONDUCTIONS

To apply such techniques in the laboratory, materials with an appreciable phonon conduction have to be used. Pure metals present difficulties because their high electronic conduction masks the phonon conduction. So alloys are studied. Work in the laboratory has concentrated on the alpha brasses in which the zinc concentration varies between 1 and 30 per cent. By careful measurement it is possible to separate the contribution of the electron and phonon conduction and to use the latter to measure the density of dislocations in a material. It then becomes possible to discover the variation of the density of dislocations with percentage of strain. This function is very useful and essential to any theory of the mechanism of work hardening. The method itself may prove superior to other methods, such as etch-pit counting and X-ray measurements. In the former the pits tend to run together, while in the latter the interpretation is difficult and very tedious to apply when variation is required rather than one isolated measurement.



A close-up of the clamping arrangement of the specimens. The lower chuck is fixed, the upper is coupled to the vibrator; the whole assembly fits snugly into the Dewar.

Superconductivity offers an alternative way of using phonon conduction to study metal properties. When a metal becomes superconducting its electrons do not interact with the atomic lattice at all and so cannot scatter lattice vibrations: the lattice heat conduction can actually improve, as there are no electrons to be scattered. In fact, at about 1° K the heat conductivity of some superconductors is almost entirely due to the lattice and the effect of work hardening on the phonon conduction can be measured easily. Experiments are being made at the Clarendon using this technique.

Other experiments are concerned with the measurement of specific heats. Contribution to the specific heat of a solid is made by the free

Continuing Research and Development

electrons and by the atomic lattice. The two contributions vary with temperature, the latter decreasing more rapidly. This differential variation is valuable, as the electron specific heat can be used to measure the effective mass of the electron in a metal. By specific heat measurements it is possible to see the manner in which the effective mass of the electron varies in different alloys according to the number of added atoms. The chief value of the effective mass is that it is not structure sensitive—as electrical and thermal conductivity are; it is one of the fundamental quantities of physical metallurgy.

The Services Electronics Research Laboratory, Baldock, Hertfordshire, was the first laboratory to build low temperature equipment relying entirely on supply of liquid helium from the NPL Collins liquefier. The equipment at Baldock has now been in use for over three years, and many experiments have been performed.

The low temperature section forms part of a group whose chief study is the electrical properties of solids. The three cryostats used are designed for versatility and simplicity—to enable time to be spent on the experiment rather than on operating the cryostat. Only liquid helium, and oxygen or nitrogen are used as coolants; so that the safety precautions necessary for liquid hydrogen are not called for. Experiments can be carried out between 1·3 °K and room temperature.

Most of the research has been directed towards understanding the electrical properties of semiconductors. Experiments have been made on the Hall effect, magnetoresistance, resistivity, and cyclotron resonance. During the past year, however, research into superconductivity has been started, and two new lines of research are in progress. One is an investigation of devices making use of superconductivity, the other is a more fundamental investigation of the transition from the normal state to the superconducting state. Research on devices is at present concentrated on a study of the performance of a computer memory cell that uses persistent currents set up in a lead film. This particular form of memory unit has the advantage of high speed, small size, and very low power consumption. Several units have been constructed and switching times of about 0·1 microsec have been obtained. Research on the superconducting transition is being made on very pure single crystals of metal. Equipment is installed at the laboratory for growing such crystals, and, in particular, the transitions in vanadium, tantalum, niobium, and their alloys are being investigated.

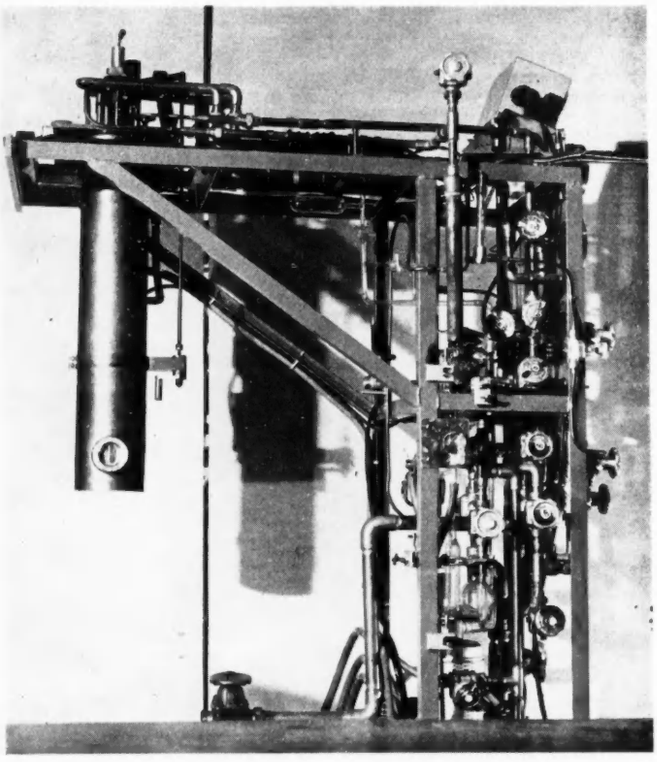
At the Research Laboratories of the General Electric Company Limited, Wembley, Middlesex, a programme of research on solids is in progress under the direction of Dr. D. A. Wright. The work involves a study of the physical properties of a number of semiconductors and insulators over a wide range of temperature. At the end of last year the facilities available were extended to allow measurements to be made down to liquid helium temperatures, the liquid helium being obtained from the NPL.

Three cryostats of all-metal construction are in operation; a fourth of glass is being installed. Measurements of the electrical conductivity and Hall coefficient of certain semi-conducting materials are made with the first cryostat, and their thermal conductivity and thermoelectric power are measured with the second. The latter, however, is portable and its low temperature chamber can be replaced by an alternative one fitted with windows of potassium bromide or silver chloride: these are transparent to infra-red radiation, and so the cryostat can be wheeled into the beam of a spectrometer for study of infra-red transmission through solids at low temperatures. A certain amount of movement must take place in the piping of the portable cryostat and, as will be seen from Fig. 9, this is provided for by metal bellows.

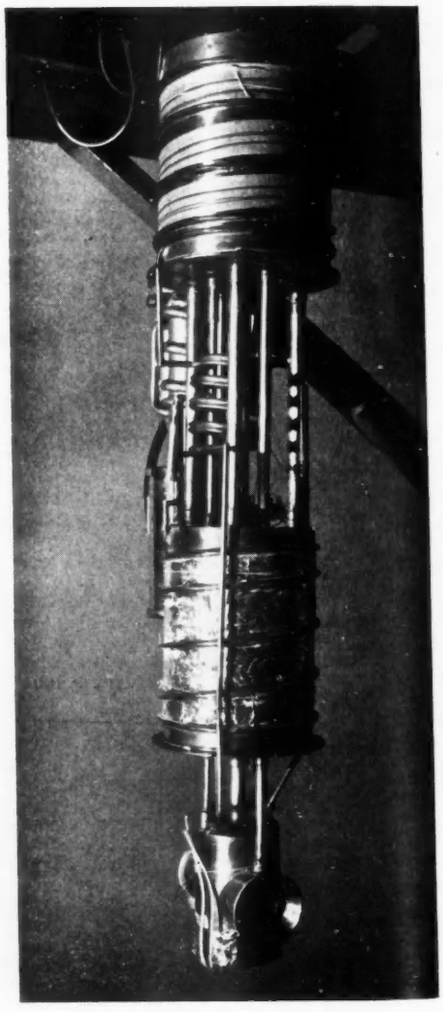
The glass cryostat will be used primarily for resonance work, especially cyclotron resonance. The technique involves pumping microwave radiation into a specimen located in an orientated magnetic field; when the electrons move in circular paths whose orbital period coincides with that of the impressed radiation, resonance occurs and energy is absorbed from the radiation. Such experiments give information on the effective mass of the electrons or holes in a semiconductor. For many applications this is an important parameter in assessing the usefulness of a semiconductor.

The other metal cryostat has been constructed by the metallurgical department of the GEC Research Laboratory. It is used in the solid physics laboratory because of the convenience in centralising the use of liquid helium, particularly from the point of view of collecting and compressing the gas evolved during experiments. This cryostat is used mainly for measurements of the electrical conductivity of metals, to gain information about impurities and defects in the crystal structure of the metal.

As Dr. Wright pointed out in an interview with our representative, in all these examples the low temperatures are being used because they improve the techniques available for studying properties of solids: for example, as a result of lowering the electron density in a semiconductor, or of increasing the electron-free path, or of decreasing the thermal vibrations. He pointed out, however, that in addition to these research applications there are increasing possibilities that devices operated by liquid helium temperatures will become part of the technology of the future, and in planning long-term research in industry, these possibilities must be kept in mind.



This cryostat is used by GEC for measuring the transmission of infra-red radiation through specimens cooled by liquid helium. The chamber on the left has to be adjustable for positioning in a spectrometer beam: this necessitates the use of bellows in the piping.



A close-up of the inside of the chamber shown on the left of the previous illustration.

Boiling Points of Gases at Atmospheric Pressure

	°C	°F	°K
Helium 3	−269·9	−453·8	3·2
Helium 4	−268·9	−452·0	4·2
Hydrogen	−252·7	−422·9	20·4
Deuterium	−249·5	−417·1	23·6
Tritium	−248·0	−414·4	25·1
Neon	−245·9	−410·6	27·2
Nitrogen	−195·8	−320·4	77·3
Carbon monoxide	−192·0	−313·6	81·1
Fluorine	−187·0	−304·6	86·0
Argon	−185·7	−302·3	87·4
Oxygen	−183·0	−297·4	90·1

Book Reviews

ORBITAL OBSERVATORIES

Scientific Uses of Earth Satellites. Edited by JAMES A. VAN ALLEN. *Chapman and Hall Limited, 37 Essex Street, London, W.C.2.* (63*s*)

It is a few years only since the reviewer was used to meeting scepticism when lecturing on the possibility (remote though it seemed) of instrument-carrying satellites and lunar probes. True it was a scepticism far removed from the scorn of a decade ago but it was sufficiently widespread for a large section of the engineering community to be set back on its collective heels by the Eisenhower announcement in August, 1955, of the Vanguard project. The success (and size) of Sputnik 1 surprised even the missile and rocket engineers on this side of the Iron Curtain. To-day, only a year after the first successful launching, a fresh attempt is lucky if it reaches the front page of most newspapers and after a couple of announcements on the BBC is scored out as "old stuff." True, some papers have been persistent in their publication of the times of arrival over Britain of the Sputniks but this does not interest the average reader who probably does not know how many satellites are circling the Earth at the moment.

Nevertheless, the average engineer, usually being endowed with a fair share of curiosity, is extremely interested in the technicalities of the satellites, their instruments and launching vehicles. It is unlikely that much will be written in detail about the launching vehicles as they are all military devices (or at least based on them) and by virtue of the very high performance required in launching, a satellite must represent the latest in missile technology. The experiments carried out and the instruments used are in a different category. At least so far as the American work is concerned the research is being undertaken by universities and other civil research organisations rather than the military. Thus most of the results and descriptions of equipment will be made generally available. Unfortunately, as is often the case with specialised work of this nature, the bulk will be published in such journals as *Jet Propulsion* and *Astonautica Acta* which are not as easily available in public and professional libraries as they should be.

It is likely to be some years before the data obtained from the satellites has been sufficiently well analysed, digested and explained for it to be presented in book form. It is therefore a pleasure to be able to recommend a book, albeit of pre-Sputnik vintage, which gives a useful and interesting description of many of the problems that may be solved by small artificial satellites. It is a compilation of 33 papers given at the Tenth Anniversary Meeting of the Upper Atmosphere Rocket Research Panel held at The University of Michigan in January, 1956. It may be thought that recent events will have made this very much out-of-date but, perhaps because most of the authors are old hands at rocket research, they have managed to cover: the mathematics of orbital motion; seeing the satellite, both optically and electronically; environmental problems of instrument design; measurements of atmospheric density, temperature and pressure; meteorological uses; visibility from a satellite; the study of solar phenomena, such as the extreme ultraviolet radiation; cosmic ray measurements; geophysical studies, including the determination of the Earth's magnetic field at extreme altitudes; radio propagation and meteorite measurements.

Some of the papers are of particular interest in view of the results now being obtained. The most startling item so far is the region of very high radiation discovered by Explorer I and confirmed by Explorer III. The radiation above 600 miles is so high that the counting equipment used was saturated, indicating a count rate of at least 20,000 counts per second, or 1,000 times the expected value. Van Allen summarises information on cosmic rays obtained from high-altitude rockets and extrapolates these to satellite altitudes. Much information is obtained from satellites by observation of their orbits and, because of the shortage of adequately equipped observatories the visual observations by amateurs has proved most useful. The smaller satellites are not large enough for this technique to be applied and one interesting proposal discussed by Hudson is the use of a 400-candle-sec flash which would be visible to the naked eye, and weighing only about 1 lb could be powered by solar energy. Some of the papers are rather mathematical and all have a physics bias but the material presented is quite fascinating.

ENGINEERING SINCE THE IRON AGE

Head of an Iron Age man whose body remained preserved in a peat bog for 2,000 years near Tollund, Denmark. The leather noose by which he was hanged was left around his neck.

The fifth and final volume of *A History of Technology* has now been published, and completes a project begun eight years ago. The work is the result of a collaboration between Imperial Chemical Industries and the Clarendon Press at Oxford.

The illustration reproduced here may be said to represent the age when engineering virtually began —the Iron Age. It appears in volume one of the history, and the original photograph was taken by Lennart Larsen of the Danish National Museum.

On the Shelf

By Frank H. Smith

On the whole, engineers are not particularly inventive when it comes to coining words. The old ones are made to serve and quite often this can lead to some confusion. For instance, a few years back when fatigue was newly fashionable it got noised around that I was to try and compile a bibliography on the subject and within a short while I had a letter from an academic type who was doing some research into the effect of repetition on factory workers, asking for any references I could provide. Which brings me to the latest set of Data Sheets of the Royal Aeronautical Society. As should be known, the R.Ae.Soc. has produced such sheets before on aerodynamics, structures, fuels and lubricants and performance. Many of these are exclusive to aeronautics but both the structures and the present fatigue data sheets have a wider application. The responsible committee bears some impressive names and application to the Society (4 Hamilton Place, London, W.1—to Mr. A. J. Barrett) will bring full details of the first 20 sheets.

The British Plastics Federation have an abstract service (10 guineas per annum) and a wide information service available to its members. The Library is at 47-48 Piccadilly, London, W.1.

Self-Changing Gears Limited (Lythalls Lane, Coventry) have produced the first number of their house journal *Transmission Times*, in which are described applications of the firm's products in all parts of the world and all sorts of vehicle.

I think I will have my tummy lined with Inconel since I see from *Corrosion-Resisting Characteristics of Wiggin High-Nickel Alloys* (Henry Wiggin & Company Limited, Wiggin Street, Birmingham 16) that beer had no corrosive effect even after 10 weeks. There is plenty of other information in this 100-page booklet.

Number 1 of Volume 1 has appeared of *Engineering Materials and Design*, a monthly at 35*s* per year. You can get the low-down from Heywood & Company Limited, Russell Street, London, W.C.2.

After I have typed this stuff, it comes back to me in the form of a proof which I am supposed to correct. Many of my corrections are Smith Specials and it is a wonder to me that either the "sub" at Bedford Street or the printer can understand them. Sometimes they evidently do not. All this will be changed. B.S.I. have produced 1219C (at 2*s* 6*d*) which is a "Table of Symbols for Proof Correction." This is the essence of B.S. 1219 and is a neat, card folder that can be kept close at hand as reference when you wish to do such things as "No fresh paragraph here," or "push down space" or "substitute or insert character over which this mark is placed, in 'inferior' position" (I have one of these marks over me all the time.) There are 64 instructions with their textual marks and marginal marks.

Tucked into the *Computer Bulletin* for October/November is a most useful list compiled by the British Computer Society (Finsbury Court, Finsbury Pavement, E.C.2). It is a list of courses available on computers in the London area.

The last time I mentioned the *Journal of the Royal Society of Arts* was to draw the attention of readers to a scholarly paper on plumbing. Much water has flowed through the cisterns since then and I now suggest that some of you may like to know of the report of a conference on Apprenticeship which appears in the October issue (price 5*s* from John Adam Street, London, W.C.2). One point strikes me. Adults appreciate the great importance to the future of industry and craftsmanship of apprenticeship. But how is one to impress this on the youth who is not in the slightest degree interested in doing a job for the joy of doing it well but only in doing the minimum of slapdash work for the maximum possible monetary return?

Construction

ECONOMIC ROOFS

RAF Hangars at Abingdon

Fig. 1 Concrete barrel vault roofs for the three bays of the new Beverley aircraft hangar under construction at Abingdon, Berks. The roofs, with prestressed beams and reinforced shells, were completed on site at ground level before being jacked on to concrete columns.

A unique method of construction has been evolved by John Laing and Son Limited, in conjunction with Ove Arup and Partners, the consulting engineers, for the new hangar being built for RAF transport command, Abingdon, Berkshire.

The hangar, when completed, will consist of three bays each capable of housing a Beverley or Britannia aircraft. The roof of each bay is formed of three reinforced concrete barrel vaults carried on a prestressed concrete framework consisting of a box beam along each face, valley beams connecting the vaults, and a gable beam enclosing each end. The roof was designed to be cast, prestressed and weatherproofed at ground level and subsequently were jacked up into position on the columns at each corner which are built up as the lifting proceeds. The bays are connected by two small link bays, each 36 ft wide, with corrugated asbestos roofing supported by reinforced concrete cantilevers projecting from the barrel vault roofs. The gross uninterrupted floor area of the hangar is 613 ft by 103 ft.

Fig. 2 Method of raising the 1,400 ton roof sections, using four 200 ton hydraulic jacks at each corner and interlocking T-shaped column units which are inserted as two of the jacks are retracted.

Fig. 3 Erecting a section of the sliding-folding doors in the front of the hangar. The structural steelwork of a lean-to annexe is shown at the rear.

CONSTRUCTION AT GROUND LEVEL

The roofs are shown in Fig. 1 almost complete at ground level before lifting. This method of construction was found to be much more economical since there was considerable saving in labour, scaffolding and plant; in addition, it was found much more convenient to carry out the work at ground level. Work on the roof commenced when the foundations, hangar floor, entrances and aprons had been completed. Building paper was laid over the floor to prevent adhesion of the roof beams which were cast on the floor. The beams were prestressed using the Freyssinet system, each roof having a total of 106 cables, each made up of 12 wires 0·276 in in diameter. Owing to the great length of the beams—each bay has a floor area of 186 ft by 110 ft—the prestressing was carried out with the aid of "walkie-talkie" radio equipment to co-ordinate operations at both ends of the beams. Travelling formwork, built on bogies, was used to cast the reinforced concrete shells which are 3¼ in thick at the crown and 5 in thick at the valleys; each vault was cast in sections as the formwork was moved along. The roof is insulated with boarding and 3-ply roofing felt to retain the heat from radiant heating panels which will be suspended from the roof and walls of the hangar. Each roof when completed is estimated to weigh approximately 1,400 tons.

RAISING THE ROOFS

Sixteen 200 ton hydraulic jacks, made by Youngs (Lifting Appliances) Limited Birmingham, 16, were used to raise the 1,400 ton roof to 46 ft above the floor. The method of lifting is shown in Fig. 2. The first stage was to raise the roof to a height of 2 ft 8 in above the ground using two jacks at each corner. This had to be done slowly taking care that the roof did not deviate more than 1 in from the level position, the operation taking six hours. The column units are interlocking and T-shaped and 1,000 units, each weighing half a ton, were pre-cast on the site for the 12 columns required to support the three roofs of the bays. To complete the lift of each roof, four jacks were used at each corner, the procedure being to lock two of the jacks and retract the other two, leaving room for the insertion of another two column units. The positioning of these units and the making of the mortar joints had to be done accurately to ensure uniform stressing of the columns. During the lift the roof was secured against wind forces by a system of guys. When the lift had been completed and the columns fully assembled the column units were prestressed using the Lee-McCall system of vertical bars, which had been inserted in cavities in the columns at the half-way erection stage, and extending from the foundations to the roof. To lift the first roof, 30 men were involved for about a week.

HANGAR DETAILS

The Air Ministry specified that the hangar should be designed to withstand loading on the roofs and working platforms of 15 and 60 lb per sq. ft respectively, the maximum wind velocity to be assumed as 85 m.p.h. and a maximum temperature variation of 45° F. Thermal insulation was required to give a "U" value of not more than 0·3 through the external walls and roof; fire resistance requirements were also specified.

At the rear of the hangar a lean-to annexe in structural steelwork is being built for office and technical accommodation. This will be supported at the top by the barrel vault roof, and at the bottom by the reinforced concrete frames of the single-storey workshops which will extend along the rear wall on the inside of the hangar. The rear and side walls will be brick to a height of 14 ft, above which there will be glazing and corrugated asbestos sheets. The front of the hangar will contain sliding-folding doors in six sections, each 90 ft wide and 45 ft high, operating in three pairs (Fig. 3).

Six designs were submitted by selected contractors. One was of aluminium construction, another a steel structure with an aluminium roof, one in pre-cast prestressed frame construction and the others were in varying designs of prestressed *in situ* construction. The accepted tender price was the lowest, 28 per cent below the highest tender.

BRITISH UNIVERSAL BEAMS IN WORKSHOP FRAME

Among the first examples of the use of British-rolled broad-flange beams is the extensions being built for Whessoe Limited of Darlington. Agreement to go ahead with the design coincided with the release of universal beams from Dorman Long (Steel) Limited at their new mill at Lackenby.* The contract for the extension was won by Redpath Brown and Company Limited, Edinburgh, who had begun to build up stocks of the new sections from the time these first came into production. The saving in weight that could be obtained by using universal beams made them preferred to standard sections.

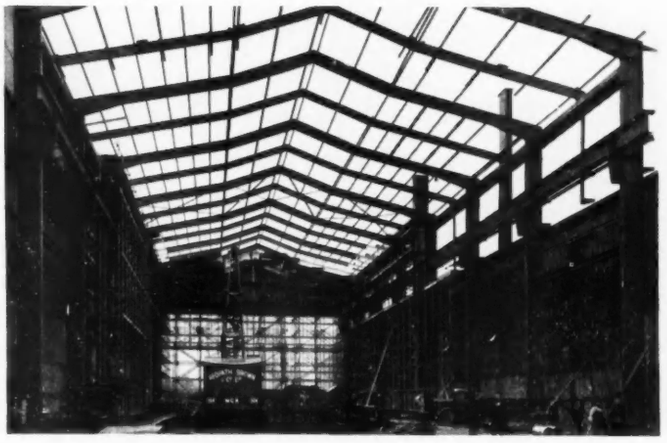
This particular Whessoe extension covers an area approximately 295 ft long by 90 ft wide with an eaves height of 57 ft. The eight main portal frames are designed with fixed bases and have a span of 85 ft 6 in. The vertical legs, weighing 7½ tons each, are made of 36 in by 16½ in by 260 lb per ft universal beams, which are the largest section of the range rolled. This section is carried up to the eaves knuckle and tapers down at the approximate point of contra-flexure on the rafter to 24 in by 12 in where it weds with the 24 in by 12 in by 100 lb per ft rafter. Each main portal was fabricated and transported in four pieces to be welded at the site into a complete unit.

Broad flange beams rolled in Dorman Long's Lackenby mill are now reaching construction sites. Their first use in portal frames is in Whessoe's extension at Darlington. The frame has a span of 90 ft and is 57 ft high to the eaves. Two 40 ton overhead cranes will run the length of the new shop.

The eaves beams are formed of a horizontal 24 in by 12 in by 100 lb per ft universal welded to the top flange of a vertical 24 in by 9 in by 76 lb universal to form a welded composite section capable of withstanding the horizontal and vertical loads imposed by the intermediate roof arches (18 in by 7½ in by 50 lb per ft).

Two 80 ft span heavy duty electric overhead cranes of 40 tons capacity, travelling in tandem, run the full length of the building on 36 in by 16½ in by 260 lb per ft universal beam gantry girders. The crane girders are designed as continuous beams, welded up to strength at the joints on site. Tie beams (12 in by 12 in by 65 lb) were introduced midway between the ground and the crane girders, further bracing being eliminated by site welding all the main longitudinal connections.

It will be seen that a variety of universal beam sections have been employed for different purposes in this building and that, by their use, no compounding of sections has been necessary to obtain the required strength, thus conserving considerable time and labour and resulting in overall economy.



One of the features, though not required in the Whessoe contract, of the Lackenby universal mill is the facilities provided for splitting the broad flange beams throughout the length of the web to provide T-sections which can be used as boom or rafter members or welded together to give an even wider range of H-sections.

* Details of the beams and their application were given in a paper read before the Institution of Structural Engineers in October 1957. A description of the mill was given in ENGINEERING for 26 September 1958, pp. 406-408.

Operation and Maintenance

HOW TO RUN A RAILWAY

The application of operational research to rail transport was the subject of a stimulating and informative paper, " The Mechanics of the Train in the Service of Railway Operation," read recently to the Institution of Locomotive Engineers by Mr. S. O. Ell. He is assistant, research and development (rolling stock) to the Chief Mechanical and Electrical Engineer of the Western Region of British Railways, and has had considerable experience in the use of operational research techniques. His first sentence—" A railway is basically an enterprise of transport in which the economic and engineering factors are inseparable "—states quite simply the setting of his paper.

The dependence between the economic and engineering factors rests on the " mechanics of the train," which he defines as dealing with the basic laws of motion of a train along the permanent way. Because railways have less freedom of movement than any other form of transport, traffic control is the most important of its three technical elements, of which the other two are the permanent way and the rolling stock. Traffic control is exercised through the medium of the time-table and this cannot be efficiently constructed except with the help of the mechanics of the train.

The need to adopt more scientific methods than had been in use hitherto did not arise until the railway modernisation scheme was launched, with its wide scale introduction of new forms of motive power and other equipment. Before this, the traffic pattern " remained uneventful in character and the technical equipment stable by nature." But as soon as any novelty is to be introduced, particularly on a large scale, forward planning becomes impossible without the help of the mechanics of the train, an indispensable element in operational research, which is, in Mr. Ell's opinion, " the only efficient way of obtaining maximum productivity of the enterprise at lowest cost and of specifying technical equipment of the right type and the right power. Warning against the pure engineering approach to the problem—" we engineers are apt to regard a railway as an aggregate of engineering constructions "—Mr. Ell quotes A. M. Wellington, a distinguished American engineer of the last century who wrote " it would be well if engineering were less generally thought of, and even defined, as the art of constructing. In a certain important sense it is rather the art of not constructing; or to define it rudely but not inaptly, it is the art of doing well with one dollar what any bungler can do with two after a fashion."

The paper is primarily concerned with the problem of making it possible for staff engaged in time-table construction, who are usually non-engineering personnel, to apply the mechanics of the train to all their problems and projects with complete freedom. They should, for example, be in a position to consider hypothetical locomotive types which, nonetheless, are capable of being constructed should research indicate such types would produce increased efficiency. Similarly, fuel consumption—with the consequent determination of re-fuelling stops, must be readily available and be " of the realistic type that is produced with the aids of the mechanics of the train." Realistic knowledge of civil engineering possibilities and of signalling enter equally into the run of the information which the operating research staff must have freely available in a form they can use.

EXPERIMENTAL QUANTITIES

The influence of many variables must be assessed in order to arrive at values which do not unduly or unnecessarily complicate either the calculations or the application of the final results. " Experience," said Mr. Ell, " has shown that this can be done."

Tractive effort and resistance can be gauged

Continuing

Operation and Maintenance

with accuracy and the resultant curves are generally valid. Rail tractive effort/speed curves are worked out from the engine b.h.p. at average ambient pressure and temperature, the parameters being engine r.p.m. with hourly fuel consumption. Variations in transmission efficiencies are not significant in modern hydraulic or electric transmission and the curves therefore rarely depart from the rectangular hyperbolas that correspond to constant power. Resistance of the locomotive and its trailing load are two of the most important experimental quantities required. It is the sum of rail and journal friction and air and wind resistance in each case and is readily determinable by a Dynamometer car.

Adhesion and maximum load are important factors. Unless they are correctly calculated, slip may occur and severe damage to the rails can result. Experiments conducted with a 2,000 b.h.p. diesel-hydraulic locomotive showed consistently that the border line between slipping and not slipping on a dry rail with ordinary sanding gear, ordinarily maintained, is reached when the starting co-efficient of adhesion is 0·276. The safe figure adopted to take in somewhat worse rail conditions (but not extreme) is 0·24. Maximum loads worked out on this value, assuming half provisions and a resistance of 20·7 lb per gross ton for passenger trains, have since been found in service to give satisfaction. A corresponding figure for freight trains, fully extended in the drawgear by the steepness of the gradients, is 32 lb per ton.

Mr. Ell considers two basic relations: first " the space-time relations for a given route, which depend on (*a*) the track profile, (*b*) the power-weight ratios and resistance of the rolling stock, and (*c*) the maximum speeds imposed by the permanent way, rolling stock, signalling, and braking power " and second the fuel consumption per gross ton-mile of trains of the same type hauled by locomotives of various specifications, each keeping exactly the same schedule, which varies with fuel consumption per b.h.p.-hour, with a factor which embraces the individual resistances and transmission efficiencies of the locomotives.

The working out of each of these basic relations is explained mathematically. They go far to substantiate Mr. Ell's statement that " the mechanics of the train can establish in a few hours what experience can do over a very long period." Various conclusions are drawn from the relations, one being that trains of the same type hauled by locomotives of various power classifications which run exactly to the same schedule have the same consumption per gross ton-mile.

The complex of the many factors which affect cost per net ton-mile, illustrated in the chart, can be handled effectively and quickly by modern operational research techniques. This was clearly impossible in Wellington's day and not so easy when Lomonossoff wrote his famous book. It is now an established process employing familiar techniques, readily understood by engineers. Much bitter controversy could have been avoided in the (not so distant) past concerning the choice of tractive power, and the genius of our railway engineers could have been harnessed to more purposive creations. But in those days, Mr. Ell's basic contention, that economic and engineering factors are inseparably intertwined and cannot be considered in isolation of one another, was barely understood and certainly far from being accepted.

Engineering at Home

TRIAL BY USAGE

About a year ago this section was inaugurated with an article welcoming the increased attention paid to consumer goods by the British Standards Institution. Since then two organisations that test consumer goods have held the field—one a part of BSI, the other an independent company. Both frequently use British Standards as a basis for their tests, although the independent company often tests beyond the requirements of a Standard. This is a commendable practice: for, valuable as Standards are, they are a minimum requirement. A useful service is rendered when those items that are just good enough to reach the Standard are distinguished from those that are exceptional.

Recently, each organisation has published the autumn issue of its magazine: *Shoppers' Guide 6*, from the Consumer Advisory Council, BSI, Orchard Street, London, W.1; and *Which*? 5, from Consumers' Association Limited, 7 Great James Street, London, W.C.1 (formerly, Association for Consumer Research Limited). Both issues are representative of the work done by each organisation, and show that although tests with a technical basis are important, they are by no means the only service offered: there are also reports on vitamin pills, glucose drinks, socks, and small savings. Some of the technical work of the two organisations is summarised below.

Oil heaters were tested by Consumers' Association Limited. There are over 50 makes of this type of heater (also called paraffin or kerosine heaters), and the Association decided to test ten —five radiant and five convectors. No pressure heaters were examined.

As an overturned heater is a possible cause of fire, all makes were tested for stability. The British Standard requires that a heater, full or empty, shall not fall over if tilted 15° from the vertical in any direction. Only one of the ten heaters failed in this respect. However, a more rigorous test was made. The fuel container of each heater was filled to capacity, the burner lit, adjusted for full flame, and left for an hour. The heater was then pushed over backwards, left on the floor for 10 seconds, and returned to normal. The procedure was repeated, with the heater pushed forwards.

With the backwards-pushing sequence, the flame in all heaters either went out or returned to normal burning. However, when the radiant heaters were pushed over forwards, the paraffin spilt and caught fire. Convectors pushed forward did not catch fire. As it is very difficult to push over the squat radiant heaters accidentally, Consumers' Association consider that all makes tested can be considered safe in this respect.

According to the British Standard, various parts of the heaters that are not " working surfaces " and might be touched accidentally should remain below certain temperatures. In all makes tested the " grille " over the burner exceeded 250° F, and so failed the test. The " grille " in the convectors is the outlet on the front of the box; in the radiators it is the guard.

The heaters were equally efficient, producing the same heat from a given amount of paraffin. There was complete combustion with all the burners and none of the flames crept out of alignment: thus there was no danger of excessive carbon monoxide in the room, which should be adequately ventilated if there is an oil heater in it. The importance of using the heaters correctly is emphasised by Consumers' Association Limited, who point out that the Fire Protection Association has a list of instructions that it suggests should be permanently fixed to a heater. Only one of the makes tested did not have most of the list attached. Such permanent attachment could well find much larger application than it does to articles other than heaters. It is more convenient than the usual instruction slip, which is often lost. Also, for the same reason, it is safer.

A report on anti-freeze solutions for car radiators is given by the Consumer Advisory Council. A table showing the freezing points for solutions containing various amounts of ethanediol (also called ethylene glycol, or glycol) is set out, together with information on the three main types of corrosion inhibitor. To find out whether the cheap brands of anti-freeze were satisfactory, three makes were examined, each costing 10*s* a quart. It was concluded that two of the brands were perfectly adequate and could be relied on. The third was the wrong colour for the Ministry of Supply specification with which it was stated to comply; it was not fluorescent, which is preferred for the easy detection of leaks; and its pH value was below that recommended, although not as low as the value the Ministry of Supply recommend to indicate that the anti-freeze solution should be discarded. The article ends with some hints on the use of anti-freeze.

Twenty-one makes of screwdriver, in popular sizes, were also tested by the Council. Blade lengths varied from 2 to 12 in. The tests were made in accordance with BS 2559 and " other appropriate Standards." In some respects, the description of the tests is lacking in information. For example, in describing their results with ratchet screwdrivers, the Council remark that of the two makes examined one was slightly more robust than the other. It would be helpful if the test made for robustness was described.

This is done by the Consumers' Association in its description of tests made on bathroom scales. These, like ratchet screwdrivers, contain a simple mechanism subjected to repeated traverse through a certain amount of movement. What interests the user is how long the mechanism will function correctly before it breaks down.

Which? describes in detail the tests carried out on several makes of scales. After the scales had been tested for accuracy by a Weights and Measures Office, and the effect of uneven loading had been examined, they were sent to a laboratory to see how well they stood up to intensive use. A 12-stone weight was put on and off each machine 2,190 times (the equivalent of 6 years usage, assuming that each machine was used once a day); dial readings were taken after the equivalent of every 9 months wear. As far as robustness was concerned the tests were revealing: after the equivalent of three years use, two of the scales failed to operate. The reason for the breakdown was that the platforms, made from a thin metal pressing, became so flexible that they jammed against the dials. After 3¼ years use, another machine's mechanism jammed. The remaining seven machines continued to give readings up to the equivalent of six years' use, but various degrees of inaccuracy were shown—one make indicating as much as 12 lb under weight. Two machines remained accurate to within 2 lb.

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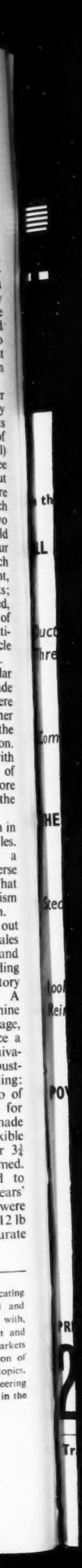
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